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Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
VOL. XXXIX. NO. 1.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, TO MARCH, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

XI.

ECHINI.

THE GENUS COLOBOCENTROTUS.

BY ALEXANDER AGASSIZ.

WITH FORTY-NINE PLATES.

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NOTE.

A small number of sea-urchins were collected during the Tropical Pacific Expedition of the "Albatross" (1899–1900), so that only a few genera and species characteristic of the Pacific will be described in succession whenever sufficient new and interesting or important material has been obtained.

The genus Colobocentrotus of Brandt remarkable for its peculiar primary radioles forms the subject of the first part of the Tropical Pacific Echini. This will be followed by a paper on the allied genus Heterocentrotus.

I have to thank Mr. Richard Rathburn of the Smithsonian for having sent me for study the types of Colobocentrotus collected at the Bonin Islands, by Dr. Wm. Stimpson, the naturalist of the North Pacific Exploring Expedition under command of Captains Ringgold and Rodgers.

I am greatly indebted to Mr. Magnus Westergren for the interest he has taken in the preparation of the Plates illustrating this Memoir. His accuracy in drawing, his knowledge of the structure of sea-urchins obtained during his long training in the preparation of plates on Echinoderms, is shown on every plate due to his facile pencil.

In addition to the material of Colobocentrotus collected by the "Albatross" during the Tropical Pacific Expedition I have availed myself of material collected by the "Albatross" at the Hawaiian Islands and in other parts of the Pacific and in the Indian Ocean, found in the collections of the Museum of Comparative Zoölogy.

ALEXANDER AGASSIZ.

NEWPORT, R. I., August 29, 1903.

TROPICAL PACIFIC ECHINI.

THE GENUS COLOBOCENTROTUS.

COLOBOCENTROTUS Brandt (A. Ag. emend.).

Colobocentrotus Brandt, 1835, Prod. p. 66.
Colobocentrotus A. Ag. Rev. Echini, p. 423 (partim).

This genus is now limited to such species as *Colobocentrotus Mertensii* Brandt and *Colob. Stimpsoni* A. Ag., the better known species, *C. atratus* and *C. pedifer*, having been separated from it and united in the genus Podophora Agass.

The following are the species of Colobocentrotus and of Podophora described in this memoir:

Colobocentrotus Mertensii Brandt.

Colobocentrotus Mertensii Brandt, 1835, Prod., p. 66.

Colobocentrotus Mertensii A. Ag. (partim) Rev. Echini, 1872, p. 103, Pl. III[a], figs. *4*, *5*, p. 426. Bonin Islands.

Colobocentrotus Leskei A. Ag. 1863. Proc. Phila. Acad. p. 354 is a slip of the pen for Colobocentrotus Mertensii Brandt.

Colobocentrotus quadriseriatus Trosch., noted by Troschel as occurring in Australia, is, I should say from his description, Colob. Mertensii Brandt.

This species was collected by Dr. Wm. Stimpson at Port Lloyd, Bonin Islands, North Pacific Exploring Expedition, under Captains Ringgold and Rodgers. It is figured in the Revision of the Echini, Plate III[a], figs. *4*, *5*.

Stimpson says it is found "in surf-washed rocks."

Colobocentrotus Stimpsoni A. Ag.

Is the large grayish pink species collected by Dr. Stimpson at the Bonin Islands, North Pacific Exploring Expedition, and described later on.

The species of Colobocentrotus have thus far only been collected at the Bonin Islands and, according to Troschel, in Australia.

Podophora Agass.

Podophora Agass. 1840, Cat. Syst. Ectyp., p. 19.

In 1840 Agassiz was not aware of the existence of Brandt's Prodromus where the genus Colobocentrotus was established.

Podophora atrata Agass.

Echinus atratus Lin. 1758, Syst. Nat. ed. X., p. 655.
Echinometra atrata Blainv., 1834, Actinol., p. 225, Pl. 20, figs. 1, 1a.
Podophora atrata Agass. 1840, Cat. Syst. Ectyp., p. 19.
Colobocentrotus atratus A. Ag. (partim), 1872, Rev. Echini, p. 102, Pl. III[a], fig. 3.
Colobocentrotus atratus Möbius, 1908, Aesthetik d. Thierwelt, fig. 5, p. 20.

Lovén in his Echin. of Lin. says that the type of Linnæus was collected at Mauritius, or rather that the original of the figure in the French edition of Klein to which Linnæus refers in his twelfth edition came from Mauritius. Leske's figure, to which Blainville and others refer as the typical *atratus*, has the longer marginal spines rounded at the tip. Blainville further states that it is "d'un blanc violet presque noir," which agrees with the coloring of the specimens from the Hawaiian Islands and Mauritius in the Museum collections.

Hawaiian Islands, M. C. Z. collections.

Hilo, Hawaii, Smithsonian (Albatross coll.).

Mauritius, Seychelles, Zanzibar, M. C. Z. collections. This species has also been noted as occurring at Java and the Moluccas.[1]

Möbius has given an excellent figure of *Podophora atrata* from Mauritius, the dark violet species with long spines rounded at the tip. *Echinometra Quoyi* Blainv. is only the young of *P. atrata*. *Colob. Leskei* Br. is probably *P. atrata*.

Podophora pedifera Agass.

Echinus pedifer Blainv. 1825, Dict. Sc. Nat. O., Vol. 37, p. 97. Mers Australes.
Podophora pedifera Agass., 1846, C. Rais. Ann. Sc. Nat. VI, p. 370.
Podophora atrata A. Ag. (partim), 1872, Rev. Ech. p. 102, Pl. III[a], fig. 3, p. 424.

The excellent description of Blainville, with his statement "couleur générale d'un vert bleuâtre, les mammelons verts, les épines livides," leaves no doubt of its identity with the greenish-olive specimens collected at Fakarava

[1] See Rev. Echini, 1872, p. 103.

by the "Albatross" Tropical Pacific Expedition 1899–1900, on the seaface of the reef exposed to the full force of the surf.

A specimen from Chili is figured in the Revision of the Echini (Pl. III[a], fig. *3*). There are also specimens of this species in the Museum collections labelled Valparaiso?, Callao, Chili, and Peru.

Colobocentrotus and Podophora.

The genus Colobocentrotus was established by Brandt in 1835; he also included in it *Podophora atrata* Agass., for which Agassiz in 1840 established the genus Podophora. With the material at my disposal I have come to the conclusion that the original Colobocentrotus of Brandt may be dismembered into two genera, — the one (Podophora Agass.) to include *P. atrata* and *P. pedifera* (Pls. 7; 20); the other (Colobocentrotus Brandt) limited to *Colob. Mertensii* and *Colob. Stimpsoni*, the former of which was the first species for which Brandt originally established the genus (Plates 33; 34; 37; 38; and 35; 36).

The species of Colobocentrotus (Plates 33, fig. *3*; 34, fig. *3*; 35, fig. *3*; 36, fig. *3*) are much flatter than those of Podophora. They are at once distinguished by the elongated coronal plates which carry a larger number of primary tubercles uniform in size (arranged in two horizontal rows) in both the ambulacral and interambulacral zones than in the species of Podophora. There are as many as twelve vertical rows of interambulacral tubercles immediately above the ambitus in *Colob. Stimpsoni* in a specimen of 65 mm. in diameter; in a specimen of *Podophora pedifera* of 55 mm. there are eight, and in a specimen of *Podophora atrata* of 45 mm. there are only six vertical rows at the ambitus.

The outline of the test of the species of Colobocentrotus is elliptical or circular, while it is pentagonal in Podophora. The general shape of the test of the species of Colobocentrotus and Podophora seems to be fairly constant. An outline of the ambitus of each of the four species (see figs. *a–d* p. 5), with their measurement and number of pores in the ambulacral plates on the abactinal side, is given for comparison.

Podophora pedifera Agass.

Length, denuded, 55 mm.
Width, denuded, 30 mm.
Height, denuded, 30 mm.

Pairs of pores in each ambulacral plate 11, 12, near the ambitus on the abactinal side.

Podophora atrata Agass.

Length, denuded, 45 mm.
Width, denuded, 38 mm.
Height, denuded, 18 mm.

Pairs of pores in each ambulacral plate 9, 10, near the ambitus on the abactinal side.

Colobocentrotus Stimpsoni A. Ag.

Length, denuded, 64 mm.
Width, denuded, 53 mm.
Height, denuded, 24 mm.

Pairs of pores in each ambulacral plate 7, 8, near the ambitus on the abactinal side.

Colobocentrotus Mertensii Brandt.

Length, denuded, 54 mm.
Width, denuded, 48 mm.
Height, denuded, 22 mm.

Pairs of pores in each ambulacral plate 7, 8, near the ambitus on the abactinal side.

The outline at the ambitus of *Podophora pedifera* (Fig. *a*; Pl. 13, fig. *1*) and of *Podophora atrata* (Fig. *b*; Pl. 25, fig. *5*) is pentagonal in both; the actinal side of *Podophora pedifera* is strongly arched, while that of *Podophora atrata* is nearly flat. The ambitus of *Colob. Stimpsoni* is ellipsoidal (fig. *d*), in *Colob. Mertensii* it is almost circular (fig. *c*). This dissimilarity can scarcely be due to age, as the difference in length of the two specimens is only 10 mm. The number of tubercles in *Colob. Mertensii* is less than in *Colob. Stimpsoni*. In *Mertensii* those in the interambulacrum at the ambitus, on the actinal side, are somewhat larger; hence that side is more concave.

Photography is often misleading when reproducing specimens of natural size, some parts are apt to be somewhat out of focus. The profiles in Plates 8, fig. *3*; 20, fig. *6*; 34, fig. *3*; and 36, fig. *3*, do not fully correspond to the diagrams (figs. *a–d*) which are correct.

A comparison of the odd anterior ambulacrum of the two species of Podophora (Pl. 46, figs. *1*, *5*), and of *Colobocentrotus Stimpsoni* (Pl. 46, fig. *9*) brings out strikingly their specific differences. In a specimen of *Podophora pedifera* Agass. of 55 mm. in diameter the ambitus crosses the fifth and sixth

plate, and the greatest width of the poriferous field is at the second and third plate from the actinostome, leaving a comparatively narrow interambulacral field (Pl. 12, fig. *1*). From the ambitus to the abactinal system the large tubercles

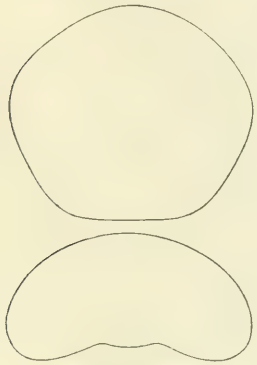


Fig. *a. P. pedifera.*

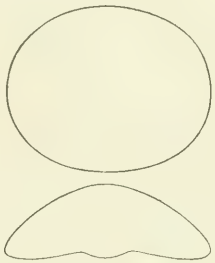


Fig. *b. P. atrata.*

occupy the whole of the ambulacral plate, leaving room only for a thin line of small miliaries. The abactinal tubercles alone have a circular scrobicular area; from the fourth plate from the apex it becomes irregular in outline,

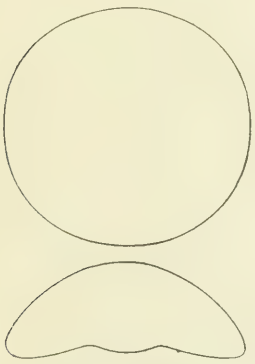


Fig. *c. Colob. Mertensii.*

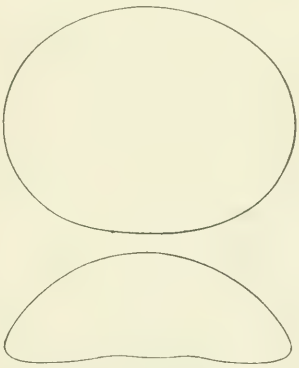


Fig. *d. Colob. Stimpsoni.*

and the pairs of pores are sometimes pushed in two arcs, or forced out towards the outer edge of the ambulacral plate. At the ambitus and on the actinal side the primary tubercles form two short rows on each side of the primary rows and then extend towards the actinostome as a single row of small secondaries

with a few miliaries on each side of the median line separating the two poriferous fields. The difference in appearance of the pores of the actinal edge of the poriferous field of the region at the ambitus and those of the abactinal side of the ambulacral system is shown on Pl. 46, figs. *2*, *3*, *4*.

The odd anterior ambulacrum of a specimen of *Podophora atrata* measuring 46 mm. in diameter is at once distinguished from that of *Podophora pedifera* by the more regular outline of the vertical rows of primary tubercles. Both the mammary boss and scrobicular area are circular in outline (Pl. 46, fig. *5*); they occupy a smaller arc of the ambulacral plates, having a larger space free from miliaries along the median line of the ambulacral zone. There are here and there a few small secondary tubercles in the inner angles of the ambulacral plates.

The vertical rows of primary tubercles extend as small tubercles to the edge of the actinal system, and numerous minute secondaries and miliaries are intercalated between the pairs of pores of the poriferous field. This is comparatively narrower than that of *Podophora pedifera*, leaving a much broader actinal interambulacral zone to separate the poriferous fields of adjoining ambulacra (Pl. 24, fig. *1*) than in *Podophora pedifera*. The change in the pairs of pores as we pass from the actinal edge to the ambitus and to one of the abactinal pairs of pores are seen in Pl. 46, figs. *6*, *7*, *8*.

In a specimen of *Colobocentrotus Stimpsoni* measuring 65 mm. in longest diameter the primary tubercles above the ambitus are of nearly the same size with a circular mammary boss and scrobicular area (Pl. 46, fig. *9*), those at the ambitus being slightly larger and those on the actinal side of the ambitus decidedly larger. In these the mammary boss and the scrobicular area are somewhat elliptical. The abactinal primary tubercles form above the ambitus four slightly undulating vertical rows with small miliaries on both sides of the median line and miliaries between the outer and inner vertical rows. Below the ambitus there are four irregularly placed large primary tubercles with a somewhat smaller one, and below that two vertical rows of small, distant secondaries on each side of the median line extending to the actinal system, with numerous miliaries and minute secondaries filling the spaces between the pairs of pores of the poriferous field.

On the abactinal side of the test there are usually three large tubercles on each plate; near the abactinal system they are reduced to two or to one with a small secondary. The poriferous arcs occupy the outer part of the ambulacral plates. There are eight pairs of pores arranged in a very open

horse-shoe shape and at the ambitus they are beginning to be crowded out of place to form the actinal poriferous field. Pl. 46, fig. *10* is a pair of pores from the poriferous field, fig. *11* a pair of pores at the ambitus, and fig. *12* one of the pores of the twelfth ambulacral plate, counting from the actinal system.

Colobocentrotus Brandt (A. Ag. emend.)

Colobocentrotus Mertensii, Brandt.

Pls. 2, figs. *8–13* ; 3ª, figs. *9–11* ; 30; 32, figs. *5–8* ; 35; 36; 39, figs. *3–4* ; 44; 45, figs. *6–10*.

Colobocentrotus Mertensii differs from *Colob. Stimpsoni* in having a more circular outline (Pl. 36, figs. *1, 2*) and being less depressed (Pl. 36, fig. *3*). It has a proportionally larger actinal system (Pl. 36, fig. *1*). The actinal surface is more sunken than that of *Colob. Stimpsoni.* The ambital edge both of the ambulacral and interambulacral zones carries much larger primary tubercles (Pl. 36, figs. *1, 3*) than those of *Colob. Stimpsoni.* The actinal lips are broad; the actinal plates of the interambulacral areas are narrower than those of *Colob. Stimpsoni.* The actinal interambulacral zone carries four irregular, vertical rows of most distinct small secondaries larger than in the corresponding zones of *Colob. Stimpsoni.*

The poriferous fields are broad, slightly sunken; the median line of the small distant ambulacral primaries consists of two vertical rows also larger than those of *Colob. Stimpsoni.* The poriferous field is studded with minute miliaries and small secondaries.

The arrangement of the miliaries on the buccal plates and of the cluster of narrow crescent-shaped plates of the actinal system (Pl. 36, fig. *1*), does not differ materially from that of *Colob. Stimpsoni* (Pl. 38, fig. *1*). The five pairs of poriferous buccal plates are somewhat larger in *Colob. Stimpsoni* than in *Colob. Mertensii.* At the ambitus there are two rows of eight large primary interambulacral tubercles. These rapidly taper to four rows of small tubercles towards the actinal system; on the abactinal side the primary interambulacral tubercles diminish gradually to the second or third plate from the ambitus and then remain of nearly uniform size, diminishing most gradually towards the abactinal system. At the fourth plate from the apex there are but six primary tubercles to each interambulacral plate, arranged in two horizontal rows; while nearer the ambitus there are eight or ten similarly arranged. The intertubercular space is filled with miliaries (Pl. 36, figs. *2, 3*).

In the ambulacral zone there are four vertical rows of large primary tubercles at the ambitus. These gradually diminish in size towards the abactinal system. On each ambulacral plate there are three primary tubercles, two, one above the other, along the median ambulacral line, the other on the distal side of the plate, surrounded by the poriferous arc. This consists of seven pairs of pores, while there are eight in *Colob. Stimpsoni.* The intertubercular space is filled with miliaries.

The abactinal system is more raised than in *Colob. Stimpsoni,* and it is covered by a coarser tuberculation of small secondaries (Pl. 36, fig. *2*). The anal system is deeply sunken; the genital pores are slightly larger than those of *Colob. Stimpsoni.* There are from ten to twelve closely packed tubercles on the genital plates, and three on the ocular plates. The madreporic body occupies the two sides of the distal part of the right anterior genital; the proximal part adjoining the anal system carries a few small secondaries and miliaries.

Colobocentrotus Mertensii, when covered with spines (Pl. 35) is of a darker ash color than *Colob. Stimpsoni.* The actinal spines of the former, corresponding to the longer small primary tubercles of that region, are longer and larger (Pl. 35, fig. *1*) than those of *Colob. Stimpsoni* (Pl. 33, fig. *1*), and the large, flat, truncated radioles are more numerous at the ambitus than in *Colob. Stimpsoni.*

In *Colob. Mertensii,* the primary radioles of the abactinal side of the test are larger than those of *Colob. Stimpsoni* (compare Pl. 35, figs. *2, 3* with Pl. 33, fig. *22*) and are also more distant, giving a freer circulation of water round the spines to the miliaries and pedicellariæ of the intertubercular areas. The small radioles covering the abactinal system (Pl. 35, fig. *2*) are more pointed than those of the abactinal system of *Colob. Stimpsoni* (Pl. 33, fig. *2*).

The order of appearance of the vertical rows of primary tubercles of *Colob. Mertensii* is shown on Pl. 39, figs. *1, 2,* which represent the arrangement of the radioles (fig. *1*) in the right posterior ambulacrum, with the right posterior interambulacrum and a part of the right anterior ambulacrum. Fig. *2* shows the arrangement of the radioles of the odd posterior interambulacrum, with the bivium and half of the right posterior ambulacrum.

Colobocentrotus Stimpsoni A. Ag.

Pls. 2, figs. *4–7*; 29; 32, figs. *1–4*; 33; 34; 37–39, figs. *4–5*; 40–45, figs. *1–5*.

A specimen of *Colob. Stimpsoni*, measuring 65 mm. when denuded, shows its elliptical outline (Pls. 34, figs. *1, 2*; 38, figs. *1, 2*). The abactinal system is slightly raised; the anal system sunken; the poriferous zone is somewhat sunken, and the genital pores are deeply sunken. The mamelon of the abactinal primary tubercles is glossy, and the general appearance of this species, when seen from above, is that it is covered with a most uniform tuberculation diminishing but slightly in size towards the apical system. Immediately at the ambitus and on both sides of it are placed the horizontal rows of the largest primary tubercles (Pls. 34, figs. *1, 3*; 38, figs. *1, 3*). A profile view (Pls. 34, fig. *3*; 38, fig. *3*) shows the nearly flat actinal side and low, subconical arched test. A view from the actinal side (Pls. 34, fig. *1*; 38, fig. *1*) shows that the actinal surface of the test is flat, the ambital edge being slightly raised. The poriferous fields are wide, extend to the ambitus, and are separated by the comparatively narrow interambulacral zone. The two median vertical rows of small ambulacral tubercles extend to the actinostome. Two still smaller additional rows of secondary tubercles run across the poriferous field about half way between the median line and the outer edge of the poriferous zone.

Seen from the interior of the test the interambulacral plates show a well marked groove in the middle of the suture of adjoining plates which is not shown in the drawings owing to the absence of shading, and the poriferous zone is raised well above the general level of the remaining part of the ambulacral plates (Pl. 42, fig. *1*).

Owing to the flatness of the test of *Colob. Stimpsoni* and the sharp angle made by the ambitus between the abactinal and actinal sides the coronal plates at the ambitus are greatly compressed and the plates very narrow (see Pl. 42, fig. *1*), this is also seen in the compression of one of the ambulacral ambital plates (Pl. 42, fig. *7*) in which the sutures between the demi-plates carrying the pairs of pores are practically obliterated. Compare this with an abactinal plate, the tenth from the actinal system (Pl. 42, figs. *5, 6*), in which (fig. *7*) the sutures of the demi-plates of the eight pairs of pores are sharply defined.

In a view of the abactinal part of the ambulacral system, seen from the

interior of the test (Pl. 42, fig. *8*, and Pl. 43, fig. *3*), it is easy to see the structure of the upper ambulacral plates. Each plate is made up of a narrow plate reaching from the median line to the outer edge of the plate and of a larger plate into which run from the outer edge half way to the median line seven demi-plates carrying seven pairs of pores. In the tenth plate from the actinostome in which the eight pairs of pores are only slightly crowded to one side (Pl. 42, fig. *5*), we see the arrangement of the three large primary tubercles and the intertubercular space occupied by the miliaries and small secondaries. A view from the inside of the left posterior ambulacrum shows the sutures indicating the composite structure of the ambulacral plate (Pl. 42, fig. *6*). In the narrow upper plate the pores marked with a small x correspond to the upper pair of pores of Pl. 42, fig. *5*, also marked with an x and on the same figure we can trace the suture of the demi-plates of the seven other pairs of pores forming the poriferous arc which extend half way from the outer edge towards the median ambulacral sutures.

In an exterior view from the actinal side of the poriferous field of the odd anterior ambulacrum (Pls. 34, fig. *1*; 38, fig. *1*; 42, fig. *3*) it is impossible to detect either the sutures of the primary plates or of the demi-plates; but in a view from the interior (Pl. 42, fig. *4*) the peculiar shape assumed by the primary actinal ambulacral plates and demi-plates, owing to the crowding and compressing of the poriferous plates is shown in Plate 42, fig. *4*. The pores marked with x in fig. *4* in the two ambulacral plates correspond to the pairs of pores similarly marked on Pl. 42, fig. *3*. The poriferous field is marked by the number of miliaries and small secondary tubercles interspersed between the pairs of pores. (Pl. 42, fig. *3*.)

The outline of one of the pairs of poriferous buccal plates of *Colob. Stimpsoni* is shown on Pl. 42, fig. *2*. They each carry a few miliaries and a number of small secondaries. The plates are originally elliptical; they abut in older specimens.

Owing to the thickness of the test the passage for the tubes leading to the pedicels slants very considerably and distant pairs as seen from the interior on figs. *4*, *6*, Pl. 42, are thus brought closely together on the exterior side of the test figs. *3*, *5*, Pl. 42.

In figs. *3*, *4*, *5*, *6*, of Pl. 42, the two minute crosses indicate the position of the pairs of pores on the inner and outer faces of the test; figs. *3*, *4* on the actinal part of the poriferous field of the odd anterior ambulacrum and figs. *5*, *6* of a pair of pores of the abactinal part of the odd anterior ambulacrum of

Colobocentrotus Stimpsoni. These figures show how the distant openings for the pedicels slant across the thickness of the test to come together and form the pairs of pores.

On Pl. 41, fig. *1*, is given a figure of the left anterior interambulacrum of a specimen of *Colob. Stimpsoni* measuring with its spines 88 mm. in diameter with 14 and 15 coronal plates. At the ambitus on the abactinal side there are 12 rows of primary tubercles which form disconnected vertical rows; at the tenth plate there are but five rows and at the third plate from the apex only three. The tubercles diminish but slightly in size from the ambitus towards the abactinal system and the intertubercular space is well filled with miliaries. Below the ambitus on the actinal side are found the largest of the primary tubercles forming two horizontal lines, the lower one of which is the largest, extending across the fifth and sixth plates from the actinal system. These tubercles carry the large flattened radioles truncated at the tip which form the ring of larger radioles round the base of the abactinal part of the test.

Between the row of large tubercles and the actinal system the interambulacral plates on each side of the poriferous field become much narrower (Pls. 41, fig. *1*; 38, fig. *1*; 34, fig. *1*). There are only four indistinct vertical rows of small primary tubercles. The rest of the plates is filled with still smaller primary tubercles and patches of miliaries irregularly arranged.

The actinal lips are short but well marked. The lower part of fig. *1*, Pl. 41, shows the distortion which takes place in the outline of the large primary tubercles below the ambitus owing to the great compression due to the formation of the sharp angle of the test at the ambitus. Fig. *3*, Pl. 41, shows one of the most distorted of the primary tubercles on the fifth plate from the actinostome, the mammary boss, and the scrobicular area being pushed out of shape. Fig. *4* shows the same tubercle in profile. Fig. *2*, Pl. 41, shows the more regular primary tubercles of the abactinal part of the test in which the boss and the scrobicular area are but slightly distorted, the boss and area being usually circular, Pl. 41, fig. *5*. The grouping of the miliaries does not seem to follow any rule. Pl. 41, fig. *6*, shows those of one of the plates near the actinostome of the right posterior ambulacrum.

In a specimen measuring 88 mm. in diameter, including the spines, it is possible to trace the twelve vertical rows of the primary radioles of the interambulacral areas. In Pl. 39, fig. *3*, the dotted lines show the twelve rows of the right posterior interambulacrum and the four vertical rows of the right poste-

rior ambulacrum. On fig. 4 of the same plate are shown the corresponding vertical rows of the right anterior ambulacrum and interambulacrum. In both the interambulacra two of the vertical rows along the median line are included by the inner and outer rows and do not extend either to the abactinal or the ambital region.

The abactinal system when denuded shows that the genital plates are covered with closely packed primary tubercles only slightly smaller than those of the rest of the abactinal surface of the test above the ambitus. (Pls. 34, fig. *2;* 38, fig. *2;* 43, fig. *2.*) There are in addition a few miliaries and small secondaries irregularly scattered between the larger tubercles.

The madreporic genital is much larger than the other genitals; the madreporite occupies the greater of the two sides of the plate. The proximal part carries two primary tubercles and from four to five smaller ones as well as a few miliaries. The genital openings are large, slightly sunken; the lateral posterior genitals are smaller than the odd posterior genital and the left anterior ones. (Pl. 43, fig. *2.*)

The genital plates are heptagonal. The left anterior genital carries no less than sixteen primaries with a few miliaries and a couple of smaller primaries. (Pl. 41, fig. *7.*) The other genitals carry from twelve to fourteen primaries with a few miliaries and secondaries.

The ocular plates are pentagonal, they carry three primary tubercles with two or three small miliaries, the ocular pores are very small. The posterior oculars approach the anal system nearer than the anterior pair or the odd ocular. (Pl. 43, figs. *2, 3.*)

The anal system is irregularly circular and covered with three to four concentric rows of irregularly shaped pointed and elliptical plates. (Pl. 43, figs. *2, 3.*)

In a specimen of *Colob. Mertensii* measuring 88 mm., when seen from above the primary radioles covering the abactinal system are seen to be somewhat smaller than those of the rest of the test (Pls. 33, fig. *2;* 37, fig. *2;* 43, fig. *1*), with the exception of a few larger triangular and elliptical ones which bridge over the anal system (Pls. 40, figs. *30-32;* 43, fig. *1*).

On Plates 33 and 37 are given views of a specimen of *Colob. Mertensii,* measuring 88 mm. in diameter. The ambital fringe of large truncated flattened primary spines carried by the larger tubercles on the actinal side of the ambitus and at the ambitus resemble slightly those of *Podophora atrata;* they are comparatively shorter and narrower (Pls. 33, figs. *1, 2;* 37, figs. *1, 2*)

than those of that species (Pls. 33, figs. *1-3;* 37, figs. *1-3*). The primaries of the abactinal side of the test are much smaller than those of Podophora and are loosely packed upon the test, leaving considerable open space round each tubercle. This open space is specially marked on the line separating the ambulacral from the interambulacral zones (Pls. 33, figs. *2, 3;* 37, figs. *2, 3*). The general color of the radioles is of a grayish pink color with a slight tinge of green on the upper surface of the larger primary ambital radioles.

Seen in profile and from the abactinal side the primary radioles which are irregularly circular at the tip are seen to diminish very gradually in size above the ambitus as they reach towards the apical system (Pls. 33, figs. *2, 3;* 37, figs. *2, 3*). The large abactinal radioles immediately above the ambitus are arranged more closely than those more distant from it (Pls. 33, fig. *3;* 37, fig. *3*).

Seen from the actinal side (Pls. 33, fig. *1;* 37, fig. *1*), the actinal membrane is nearly bare, carrying but few small clusters of miliary spines on the pairs of poriferous plates and a few minute spines irregularly scattered over it. (Pls. 33, fig. *1;* 37, fig. *1*). The actinal side of the test below the ambitus is covered with slender somewhat club-shaped spines varying but slightly in shape or size between the actinal system and the actinal side of the ambitus. The poriferous fields are separated by wide interambulacral zones (Pls. 33, fig. *1;* 37, fig. *1*).

The spines of the actinal system close to the teeth are short, club-shaped, slightly flattened (Pl. 40, fig. *1*); those from the buccal membrane are somewhat longer (Pl. 40, fig. *2*). Half way between the actinal system and the ambitus the radioles are much stouter and only slightly club-shaped (Pl. 40, figs. *3, 4*), as are the smaller spines found on the smaller secondary granules or larger miliaries (Pl. 40, fig. *5*); these spines are all delicately striated with an ill-defined milled ring.

Below the ambitus we pass suddenly to much larger flattened, angular radioles, rounded at the tip, with a large base for the muscular attachment (Pl. 40, figs. *6–8*). These spines form a part of the principal subambital fringe of radioles, the primary radioles of which are figured on Pl. 40, figs. *9–11*; these radioles resemble those of *P. pedifera*, but are comparatively shorter and narrower; they are flat on the lower surface, somewhat spathiform on the upper surface, and greatly flattened towards the tip of the radiole, as is shown by a profile view (Pl. 40, figs. *9, 11*).

We now come to the larger spines of the abactinal pavement immediately

above the ambitus; they are highly asymmetric, fan-shaped, and polygonal (Pl. 40, figs. *12–14*); somewhat more abactinally from the ambitus the polygonal radioles are smaller (Pl. 40, figs. *15–17*); midway between the ambitus and the abactinal system the primary radioles of the odd ambulacrum are slightly smaller than those nearer the ambitus (compare Pl. 40, figs. *18–20*, to Pl. 40, figs. *21–23*); nearer the abactinal system the radioles have become still smaller (Pl. 40, figs. *24*, *25*; and Pl. 40, figs. *26*, *27*). Pl. 40, fig. *28*, is one of the miliary spines from the upper extremity of the right posterior interambulacrum, hidden by the larger primary radioles. Figures of some of the primary radioles of the anal system are given on Pl. 40, figs. *29–32*.

Seen from the interior, there is a small triangular plate between the actinal plates of the odd posterior interambulacrum (Pl. 43, fig. 7) and of the right anterior interambulacrum, which may be the remnant of the primordial plates of these interambulacra.

Podophora Agass.

Podophora atrata Agass.

Pls. 2, figs. *1–3*; 3ª, figs. *5–8*; 16, figs. *9–14*; 17–28; 31, figs. *5–8*.

A fine specimen of *Podophora atrata*, measuring 97 mm. including the spines, is figured on Pl. 21ᵇ. It was collected, with others, by the Hon. Nicolas Pike, at Mauritius. When seen from above, it is of a dark violet, almost black; seen from the actinal side the marginal spines are of a light violet color towards the tip, passing to a very light shade of the same color. The smaller flattened and elongated actinal spines, as well as the miliary spines of the buccal plates, are of the latter shade; the actinal membrane is chocolate brown. The larger marginal spines are of a somewhat lighter color on the upper side, with a tinge of green; the upper surface is also coarsely and irregularly granular and pitted. On the lower side they are smooth or only slightly pitted near the tip.

A very interesting specimen of *Podophora atrata* from Mauritius is figured on Plate 21ª, figs. *1–3*. It is marked for the abnormal development of a number of the ambital radioles. Instead of being merely cylindrical as is the case in the large majority of the specimens examined they are club-shaped and proportionally larger than the ambital radioles usually are. Their shape reminds one somewhat of the club-shaped spines of *Cidaris Blumenbachii*.

The actinal system of *Podophora atrata* is pentagonal (Pls. 20, fig. *2;* 21, fig. *1*). The lips of the gill cuts are short, sharply marked; the proportion of the actinostome to the test is as 23 to 38. There are five pairs of small rectangular poriferous plates. The buccal membrane is only covered by a few round or elliptical plates irregularly scattered and with five clusters of narrow crescent-shaped plates placed distally next to the pairs of poriferous plates.

In a smaller specimen (Pl. 25, fig. *2*) the poriferous buccal plates form a nearly closed ring, the elongated buccal plates are less closely packed than in older specimens, and the isolated circular plates are more distant.

The changes which take place in the interambulacral zones during the growth of the test are shown on Pl. 24, figs. *1–4*, giving the left anterior interambulacrum of specimens measuring 8, 14, 26, and 45 mm. in diameter. In fig. *1*, the same as Pl. 25, figs. *1–5*, there are six and seven interambulacral plates, each carrying a large or small primary tubercle, with a number of miliaries or small secondaries along the median line and the outer edge of the plates.

On Pl. 24, fig. *2*, a specimen measuring 14 mm. in diameter, there are eight and nine interambulacral plates, and a second vertical row of primary tubercles is forming along the median line of the fourth and fifth plates, as well as another vertical row of small secondaries on the outer edges of the third, fourth, fifth, sixth, and the second, third, fourth, fifth plates counting from the actinostome.

On Pl. 24, fig. *1*, these two outer vertical and median rows can be detected by the greater size of the small secondary on each side of the two primary rows in the position of the new vertical rows well developed in fig. *2*. In the next stage of the same interambulacrum figured, a specimen measuring 26 mm. in diameter (Pl. 24, fig. *3*) with eleven and eleven plates, the four vertical rows of primary tubercles are well developed. The first rows, so prominent in figs. *1*, *2*, are still readily distinguished from the two inner and the two outer rows by the greater size of the primary tubercles, which extend from the second to the seventh plate, while the two inner rows extend the one from the fourth to the eighth plate, the other from the fifth to the eighth plate.

In the specimen, figured on Pl. 24, fig. *2*, the miliaries are proportionally much more numerous than in the younger specimen (Pl. 24, fig. *1*); they are quite crowded in the next stage (Pl. 24, fig. *3*), and in the older specimen, 45 mm. in diameter, they are somewhat more openly arranged (Pl. 24, fig. *4*).

In this specimen there are twelve and twelve plates; the outer vertical rows extend from the second to the ninth and perhaps to the tenth plate, the inner median rows from the fourth to the ninth plate. There still exists a marked difference in the size of the primaries of the first vertical rows near and at the ambitus compared to the primary tubercles of the other rows, which, with the exception of the upper tubercles, are nearly of the same size. It will be noticed that the outline of the scrobicular areas and of the mammary boss varies greatly; they are circular, angular, or elliptical according to their position in the plate and the amount of space available (see Pl. 24, figs. *5*, *7*, *8*). These changes are due to the great pressure brought about, especially at the ambitus, by the sudden change of direction in the plates passing from the abactinal side to the ambitus and to the actinal surface. It will be seen that in the large specimen (Pl. 24, fig. *4*) there are on the actinal side four vertical rows of small secondary tubercles separating the adjoining interambulacral rows (Pl. 24, fig. *4*).

The order of appearance of the tubercles of the vertical rows can be equally well traced in specimens covered with radioles. On Pl. 25, fig. *1*, is seen a young specimen 14 mm. in diameter with the spines having but two vertical rows of large primary tubercles, as in Pl. 24, fig. *1*, and Pl. 25, figs. *3*, *4*. Pl. 25, fig. *1*, shows the pavement of radioles of the five ambulacral and interambulacral zones, each with two rows of primary radioles and the pavement covering the abactinal system. This is shown more in detail on Pl. 22, fig. *1*. In fig. *2* of the same plate, in a somewhat larger individual, we can see the first trace of the spines of the inner vertical row of tubercles. This is somewhat more advanced in the next largest specimen figured, Pl. 22, fig. *3*. In a specimen of 26 mm. the small radioles of two of the plates of the outer rows can be distinguished; those of the inner median rows are well seen. In the next stage these radioles have all become larger and more prominent (Pl. 22, fig. *4*). In the following stages, from specimens measuring 31 mm. to 77 mm. in diameter, the mode of appearance of the radioles becomes more and more apparent and the vertical lines of primary tubercles more distinct (Pl. 22, figs. *5–10*). In Pl. 22, figs. *5–7*, the distinctness of the outer vertical zones and of the inner median zones becomes clearer with increasing size, and in the specimens of Pl. 22, figs. *8–10*, of 67 to 77 mm. in diameter, the dotted lines on the radioles show the course of the primary vertical row with the dotted lines marking the position of the lateral and median vertical lines.

The denuded test of Pl. 24, fig. *4*, corresponds nearly to that of Pl. 22, fig. *10*, covered with spines; that of Pl. 22, fig. *6*, to a stage intermediate between Pl. 24, figs. *2* and *3*.

In a small specimen of *Podophora atrata* the actinal plates of the odd interambulacral zone did not show any trace of the primordial plate (Pl. 26, fig. *11*).

The passage of the regular poriferous arcs into the laterally expanded poriferous field on the actinal side of a specimen 45 mm. in diameter is shown on Pl. 25, fig. *10*, where the upper plate is on the abactinal surface and the lower plate on the actinal side of the test, the former having an arc of nine poriferous plates, the other of eleven pairs of pores arranged diagonally across the outer part of the plate, which is considerably larger than the plate above it (Pl. 25, fig. *10*). The lower poriferous pair is pushed towards the median ambulacral line.

In a younger specimen of 8 mm. in diameter (Pl. 25, fig. *7*), taking the same plates of the odd ambulacral zone partly on the actinal side and partly above the ambitus, we find on the abactinal side the same arc of nine poriferous plates arranged round the base of the primary ambulacral tubercle, and on the actinal side thirteen pairs of pores arranged diagonally across the outer side of the more elongated actinal ambulacral plates preceding it.

The arrangement of the arcs of poriferous plates on the abactinal side of the test is seen on Pls. 20, figs. *4, 6;* 21, figs. *2, 3;* 25, figs. *3, 4, 5*, and the subsequently developed actinal poriferous field on Pls. 20, fig. *2;* 21, fig. *1;* 25, figs. *2, 6, 9*. There are many miliaries in the poriferous field (Pl. 25, fig. *9*) in marked contrast to their absence in *P. pedifera.*

A figure of *P. atrata* from the actinal side showing the arrangement of the poriferous field has been given by Lovén, (Études Pl. XVIII, fig. *158*).

The arrangement of the abactinal part of the ambulacral system of *Podophora atrata* is somewhat different from that of *P. pedifera.* The youngest plate is at once followed by a plate cut in two by an upper poriferous plate extending across the ambulacral plate and followed by nine poriferous demiplates; these extend from the edge of the interambulacral zone half way to the median ambulacral line (see Pl. 26, figs. *15, 16*).

In an interior view of the abactinal part of the test (Pl. 25, fig. *5*) the arrangement and number of the ambulacral plates are clearly drawn and the succession of the large and small ambulacral plates well indicated. In a part of the odd anterior ambulacrum of a larger specimen, 45 mm. in diameter, we can follow close to the ambitus the beginning of the widening of the

ambulacral plates and the flattening of the smaller intercalated plate (Pl. 26, fig. *14*). In *Podophora atrata* there are larger miliaries than in P. pedifera along the median ambulacral line (Pl. 21, fig. *3*).

In *P. atrata* the pavement of radioles covering the abactinal system is made up of more irregularly shaped radioles than in. *P. pedifera* (Pl. 26, figs. *2*, *4*). Both the genital and ocular plates are more elongate than those of *P. pedifera*, and the genital plates carry from two to four small secondaries with a few small miliaries irregularly scattered. The ocular plates, as in *P. pedifera*, also carry one small secondary tubercle, with five to ten small miliaries (Pl. 26, fig. *3*). In all the species both of Colobocentrotus and Podophora the ocular plates of the bivium are nearer the anal system than those of the trivium. The right anterior genital plate is nearly covered by the madreporite, and carries a few small secondaries along the median line with two or three clusters of miliaries.

In a smaller specimen (Pl. 25, fig. *3*) there are few miliaries on the abactinal system (Pl. 26, fig. *1*), with three to four secondary tubercles of uniform size on the genitals, and few miliaries. Seen from the interior (Pl. 25, fig. *5*) the sutures of the abactinal system are well shown. The madreporite is a narrow band extending across the anterior extremity of the right anterior genital (Pls. 26, fig. *1;* 25, fig. *3*).

The genital pores are proportionally smaller in *P. atrata* (Pl. 26, fig. *3*) than in *P. pedifera*, and are placed as in that species at the very tip of the genital plates. In the young specimen (Pl. 26, fig. *1*) there is as yet no trace of genital pores, but the ocular pores are well developed.

Pl. 26, fig. *5* shows the anal system of a specimen measuring 8 mm. in diameter (Pl. 26, fig. *1*), with eight plates covering the whole anal system. In a somewhat larger specimen the number of plates has increased, and they are not as regularly arranged. In a still larger specimen there are two rows of plates, the outer one being composed of large triangular ones (Pl. 26, fig. *7*), and in a specimen of 45 mm. in diameter (Pl. 26, fig. *8*) we have a magnified view of the anal plates of Pl. 26, fig. *3*.

The principal types of radioles of *Podophora atrata* are represented on Pl. 23.

Fig. *1* is a small spine from the actinal membrane near the teeth.

Figs. *2–5* are from the odd ambulacrum and the left anterior interambulacrum near the actinal system.

Figs. *6–8* are views of a slightly flattened primary radiole from the left posterior interambulacrum from the actinal side of the ambitus.

Figs. *9–11* are drawings of the characteristic stout elliptical radioles of *P. atrata*, rounded or slightly pointed at the extremity, taken from the ambitus where they form a ring at the base of the pavement of polygonal radioles extending from the abactinal side of the ambitus to the apex. The ambital radioles are from 15 to 20 mm. in length, and of a dark violet color, almost black on the upper side; on the actinal side the color of the spines is yellowish or light brown. These large radioles are finely striated, of a dark violet, with a well-marked milled ring. Blainville writes "d'un violet fonçé presque noir."

Figs. *12–14* are views of short triangular radioles from the ambitus which form a part of the abactinal polygonal pavement of the test; they are taken from the left posterior interambulacrum.

Figs. *15–17*, views of a somewhat mushroom-shaped hexagonal or polygonal radiole taken from the abactinal side of the ambitus, from the right posterior ambulacrum.

Figs. *18–20* and figs. *21–23* are polygonal radioles taken from the right anterior interambulacrum from the abactinal side of the ambitus; and figs. *24*, *25* is a similar radiole taken from the right posterior interambulacrum.

Figs. *26–28*, drawings of a low mushroom-shaped asymmetrical polygonal radiole taken from half way between the ambitus and the abactinal system.

Figs. *29–31* is an irregularly hexagonal radiole taken from the genital plates; fig. *32* is a radiole taken from the madreporic genital; and fig. *33* represents a miliary spine hidden by the large pavement of abactinal primary radioles.

It will be seen on examining the figures of radioles given on Plate 23 that, with the exception of the spines of the actinal side and of the miliary spines, all the radioles are asymmetrical.

The striking difference between the radioles of *Podophora pedifera* and those of *Podophora atrata* is well shown on comparing Pl. 11, figs. *11–13; 14–16*; *17, 18; 20–21; 22–24; 25–27; 28–30; 31–33* with Plate 23, figs. *7–8; 9–11; 12–14; 15–17; 18–20; 21–23; 26–28; 29–31*. The most marked differences are in those of the ambital radioles (compare Pl. 11, figs. *11–13* with Pl. 23, figs. *9–11*).

Podophora pedifera Agass.

Plates 1; 3[a], figs. *1–4;* 4–16, figs. *1–8;* 31, figs. *1–4*.

This species was figured in the Revision of the Echini (Pl. III[d], fig. *3*), under the name of *Colobocentrotus atratus*, and noted as having been collected

at Callao. A number of specimens were collected by the "Albatross" at Fakarava on the sea-face of the reef, during the Tropical Pacific Expedition, 1899–1900. An alcoholic specimen in the Museum collection is labelled Valparaiso? It would seem, therefore, that *Podophora pedifera* is characteristic of the Eastern Pacific, extending from Peru and Chili as far as the Western Paumotus, while the typical *Podophora atrata*, figured by Blainville, extends from the Hawaiian Islands to Mauritius, the Seychelles, and Zanzibar.

Seen from above the color of the test is olive green, darkest near the abactinal system, the pavement of radioles near the ambitus becoming lighter in color with a purplish tint; the large marginal spines are greenish with an occasional tinge of purple. Seen from the actinal side the color of the marginal and flattened elongated actinal spines is of a dirty yellow color, the large marginal radioles being of a light brownish pink at the tip. The actinal membrane is dark brown.

Podophora pedifera and *Podophora atrata* are readily distinguished. The row of primary, flat, truncated radioles which forms a close ring round the test at the ambitus in *P. pedifera* (Pls. 7, figs. *1–3*; 9, figs. *4–6*) is in striking contrast to the corresponding ring of radioles in *P. atrata*, which consists of flattened elliptical radioles rounded at the tip and well separated one from the other (Pl. 20, figs. *1, 3, 5*). A comparison of the corresponding figures of Plates 7, 9, and Plates 20, 21[a], 21[b], shows this contrast at once. The abactinal radioles of *P. pedifera* above the ambitus form a close pavement of irregularly shaped low radioles closely fitting together, of a prevailing hexagonal outline, while the corresponding pavement of the low radioles of *P. atrata* consists of radioles of a rather rhomboidal or pentagonal outline and less frequently hexagonal (compare Pls. 20, figs. *3, 5*; 21, figs. *4–6* with Pls. 7, figs. *2, 3*; 9, figs. *5, 6*). The outline of the test is higher, more arched in *P. pedifera* (Pls. 7, fig. *3*; 8, fig. *3*; 9, figs. *3, 6*) than in *P. atrata*, which is flatter and slightly conical (Pls. 20, figs. *5, 6*; 21, figs. *3, 6*). *P. atrata* is very much flatter on the actinal side (Pls. 20, figs. *1, 2, 6*; 21, figs. *1, 3, 4*) than *P. pedifera* in which the actinostome is somewhat sunken (Pls. 8, figs. *1, 3*; 9, figs. *1, 3, 4*). The ambulacral poriferous zone is also proportionally much wider in *P. pedifera* (Pls. 8, fig. *1*; 9, fig. *1*) than in *P. atrata* (Pls. 20, fig. *2*; 21, fig. *1*) where the median rows of tubercles of the ambulacral zone extend far towards the actinostome (Pls. 20, fig. *2*; 21, fig. *1*), while in *P. pedifera* the corresponding ambulacral tubercles extend but little beyond the ambitus (Pls. 8, fig. *1*; 9, fig. *1*). The actinal interambulacral zone is also much broader

in *P. atrata* (Pls. 20, fig *2;* 21, fig. *1*), while it is quite narrow in *P. pedifera* (Pls. 8, fig. *1;* 9, fig. *1*). In the latter there are two rows of small primary tubercles, while there are four in the former.

Figures *4* of Plates 9 and 21 show how large an area of the actinal surface is occupied by the closely packed ambulacral suckers, and we can judge of the great power exerted by these numerous suckers in keeping hold of the rock to which they are attached even when exposed to the full action of the surf on the outer beach of a coral reef. The sea has practically no hold on the pavement of radioles which covers the abactinal side of the test, and thus with the ambulacral suckers a cup is formed which it is difficult to detach from the rocks.

The large and small primary tubercles of *P. pedifera* are comparatively larger than those of *P. atrata;* the former occupy nearly the whole of the interambulacral and ambulacral plates leaving but little space for the smaller secondaries and miliaries, while in *P. atrata* the tubercles leave quite a part of the plate bare which carries a few miliaries and small secondary tubercles, and is covered by an indistinct granulation. In both these species the tubercles are most prominent, very glossy as if they were rounded beads made of wax (Pls. 8, 20, figs. *4, 6*).

The tubercles diminish somewhat in size from the ambitus towards the abactinal system (Pls. 8, fig. *3;* 9, fig. *3;* 20, fig. *6;* 21, fig. *3*) which is covered by small secondary tubercles, with the exception of the anal system; but even that is completely hidden by the pavement of secondary radioles on the genital plates which lap over the anal system and conceal it (Pls. 7, fig. *2;* 20, fig. *3*, and Pls. 9, fig. *5;* 21, fig. *5*). The genitals carry a few miliaries. In both these species the anal system is covered with two or three irregularly concentric rows of small triangular plates (Pls. 9, fig. *2;* 21, fig. 2). According to the size of the specimens there are in *P. pedifera* from six to eight large tubercles at the ambitus in the interambulacral areas forming six to eight vertical rows, of which only two extend to the actinal system. There are but two vertical rows of primary tubercles in the ambulacral zones (Pl. 9, fig. *3*), with a few small miliaries along the median line. Towards the abactinal system a few small secondary tubercles occupy a part of the outer edges of the interambulacral plates. On the actinal side towards the actinostome the primary tubercles of the ambitus are soon replaced by small secondaries both in the ambulacral and interambulacral areas (Pls. 8, figs. *1, 3;* 9, figs. *1, 3;* 20, fig. *2;* 21, fig. *1*).

A comparison of the left anterior interambulacrum of a denuded specimen

of *Podophora pedifera* measuring 55 mm. in diameter (Pl. 12, fig. *1*) with the same interambulacrum of *Podophora atrata* of a somewhat smaller specimen (Pl. 24, fig. *4*) will show at once the great difference there is in the tuberculation of the two species of the genus Podophora. Their development results in the one case (*P. pedifera*) in a specimen of twelve and thirteen plates to four vertical rows, and in the other (*P. atrata*) to three vertical rows on each interambulacral plate in a specimen of twelve and twelve interambulacral plates. The narrowness of the actinal part of the interambulacral zone is very marked as contrasted to *P. atrata* (Pl. 12, fig. *1*), as well as the extension of the lip of the gill slits to the fourth plate from the actinostome separating the two outer vertical zones from the inner ones. The difference in outline of the scrobicular areas and the mammary boss of this species (Pl. 12, figs. *2–6*) is as marked as in *P. atrata*. There are fewer miliaries than in *P. atrata*, owing to the comparatively larger size of the primary tubercles which leave less space between the scrobicular areas of the primary tubercles for their development.

I have given figures on Plate 10 showing the order of development of the primary tubercles of some large specimens of *P. pedifera* measuring from 76 to 87 mm. in diameter (Pl. 10, figs. *1–6*). We can trace in all the figures the radioles belonging to the two outer vertical rows, those of the primary row, and those adjacent to the median line. As will be seen on examining the figures, the position of the radioles shows the greatest regularity in the growth of the eight vertical rows of the interambulacral system of *P. pedifera* just as they did in the growth of the six vertical rows of the interambulacral zone of *P. atrata*. Seen from the interior of the test the plates of the right anterior interambulacra adjoining the actinal system show what seems to be the irregular remnant of the primordial plate (Pl. 14, fig. *8*). Such a plate does not exist in the odd posterior interambulacrum (Pl. 14, fig. *9*).

In a section of *P. pedifera* (Pl. 13, fig. *1*) the outline of the test at the ambitus is seen to be pentagonal, the point of the pentagon running across the median line of the odd posterior interambulacrum. The pentagon of the actinal system runs in the opposite direction. The gradual narrowing up of the interambulacral plates at the ambitus is shown from the same figure, as well as the tufts of miliary spines rising at the base of flattened primary spines in both the ambulacral and interambulacral areas.

The abactinal part of the ambulacral system consists of simple pairs of pores, the secondary plates of which extend about two thirds across the primary plates (Pl. 13, fig. *8*). The second plate has eight pairs of pores, the upper

plate only six; the ambulacral plates are much cut up, there being seven plates and demi-plates in the length of two plates.

The poriferous arcs extend down to a little above the ambitus (Pls. 8, figs. *2, 3;* 9, figs. *2, 3*), where the regular arrangement of the pores begins to be disturbed and they become crowded laterally, see Pls. 8, fig. *1;* 9, figs. *2, 3*. Below the ambitus on the actinal side the pairs of pores are thrown aside laterally and greatly crowded (Pl. 13, figs. *3, 4*), as is shown in Pl. 13, fig. *3*, on the actinal side, and Pl. 13, fig. *4*, from the interior of the same plates. There are but few miliaries in the poriferous field (Pl. 13, fig. *3*). The passage of the regular arcs into the broad poriferous field is well shown for *P. atrata* on Pl. 25, figs. *6–10*. The apical system and the arrangement of the pores of the abactinal part of the ambulacral system of a large specimen measuring 82 mm. is seen on Pl. 14, fig. *4*. In the second plate from the apex the upper demi-plate is followed by a row of seven poriferous plates which extend across the plate towards the median line, and beyond the projection of the large plate and its last pair of pores. When we come to the fifth ambulacral plate, counting from the actinal system, there are eleven pairs of pores arranged in a huge arc round the base of the primary tubercle. The upper pair is pushed out laterally well toward the median line (Pl. 13, fig. *6*). The corresponding ambulacral plates seen from the interior (Pl. 13, fig. 7) are seen to be made up of a large plate and a narrow, elongated, and smaller plate, the large plate having nine intercalated poriferous demi-plates extending about two thirds across it from the side of the interambulacrum; the small plate having two intercalated poriferous plates. The inner line of sutures of the intercalated poriferous plates forms a slightly zigzag-shaped vertical line more or less parallel to the median ambulacral line.

In *P. pedifera* the actinal system is proportionally larger (Pls. 8, fig. *1;* 9, fig. *1*) than in *P. atrata*. The ratio of the actinostome to the test is as 28 to 46. The pairs of poriferous actinal plates are elliptical and larger than in *P. atrata;* they are more distant from the teeth and are fairly covered with secondaries and miliaries. The buccal membrane is nearly covered with a belt of crescent-shaped plates somewhat more closely packed distally from the five pairs of poriferous plates (Pl. 13, fig. *2*). Between the teeth and the buccal poriferous plates there is a ring of small elliptical plates (Pls. 7, fig. *1;* 8, fig. *1;* 9, figs. *1, 4;* 13, fig. *2*).

The thin folds of the actinal cuts extend almost to the ambitus, enclosing in a sort of furrow the two rows of small secondary interambulacral

tubercles which extend to the actinostome (Pls. 8, fig. *1;* 9, fig. *1;* 12, fig. *1*).

In the abactinal system of *P. pedifera* the genital plates (Pl. 14, fig. *3*) carry from two to three large secondary tubercles with one to three very small secondaries or miliaries in the angles of the plates adjoining the anal system. The genital plates are irregularly heptagonal, the anterior plates elongate, the posterior broader than long. The ocular plates are pentagonal with a broad base curved towards the ambulacral system. They carry one large secondary tubercle, sometimes also a couple of miliaries, and have a well-marked ocular pore.

The madreporic genital is elongate, carries three large secondary tubercles, one in the centre of the plate, the others near the anal system, with five to six small secondaries. The madreporite occupies the greater part of the genital. Seen from above, covered with radioles, the abactinal system (Pl. 14, fig. *1*) forms a close pavement of irregular pentagonal plates which completely hide the anal system.

The genital pores are large. They occupy the distal points of the genital plates. They are well seen on Pl. 14, fig. *4*, an interior view of the abactinal system. This figure also shows the simple arrangement of the abactinal pairs of pores above the few intercalated demi-plates. The anal system is circular, covered with three to four rows of small, irregular, elliptical plates.

There is a great contrast between the genital plates of *P. pedifera* (Pl. 14, fig. *3*) with its three large secondary tubercles closely wedged together, and the genital plates of *P. atrata* with its four distant, large secondary tubercles (Pls. 25, fig. *8*; 26, figs. *1*, *3*).

On Plate 11 has been figured a series of spines of a specimen measuring 82 mm. in diameter selected to represent the great difference and variation among the primary radioles of the ambital and abactinal part of the test as well as of the spines of the actinal region and of the miliary spines hidden by the pavement of primary radioles of the abactinal system (Pls. 11, fig. *1;* 46–48). Figure *1* also shows the great development of the powerful muscular system which holds the radioles in place upon their corresponding primary tubercles. Figures *2–10* of Plate 11 show the shape of the radioles of the plates of the buccal membrane of the actinal system and of the first plates of the odd anterior ambulacrum and anterior interambulacrum. These radioles are all finely striated, somewhat club-shaped, slightly flattened towards the tip, with an indistinct milled ring and a deep socket at the base of the radioles.

The ambulacral radioles near the ambitus (Pl. 11, figs. *9, 10*), are the first to show a marked flattening and to approach in outline the large, flattened, spatula-shaped radioles of the ambital region (Pl. 11, figs. *11–13, 14–16*). The principal and most characteristic row of primary radioles (Pl. 11, figs. *11–13*) is at the ambitus and it is the one which with the pavement of abactinal primary radioles gives to Colobocentrotus and Podophora their striking characteristics. These ambital radioles vary in length from 15 to 18 mm.; they are olive-green in color.

It is interesting to follow the gradual changes which take place in the ambital radioles (Pl. 11, figs *11–13*) as they are succeeded by the more abactinal radioles (Pl. 11, figs. *14–16*) and gradually form more pavement-like, hexagonal, somewhat shorter radioles (Pl. 11, figs. *17, 18*), to be followed by still shorter radioles (Pl. 11, figs. *19–21*), and then the irregular, short, mushroom-shaped polygonal or hexagonal radioles (Pl. 11, figs. *22–24; 25–27; 28–30; 31–33*), on the thirteenth plate counting from the actinostome. A series of small, mushroom-shaped radioles has also been selected from the ocular and genital plates. They continue the abactinal pavement over the abactinal system (Pl. 11, figs. *34–36; 37–39; 40, 41; 42, 43; 44, 45*). The color of the primary radioles is olive green. It will be observed that with the exception of the radioles of the actinal side and of the miliary spines all the radioles are asymmetrical.

The Lanterns and Auricles of Colobocentrotus and Podophora.

Plates 13, figs. *1–4;* 14, figs. *5–7;* 15; 26, figs. *9–13;* 27; 28; 42, figs. *1–4;* 43, figs. *4, 5;* 44.

The differences in the various parts of the lanterns of *Podophora pedifera* and *P. atrata* are very marked; they are seen in the shape of the compass (Pls. 15, figs. *13 a b;* 27, figs. *14 a b;* 28, figs. *11 a b*), in the proportions of the corrugations of the sides of the pyramid (Pls. 15, figs. *4, 5, 8, 9 a b;* 27, figs. *4, 5, 7, 8 b;* 28, figs. *4, 5, 7 b, 8 b*); they are much coarser and less numerous in young specimens (see Pl. 27, figs. *4, 5, 7, 8*). The foramen of the pyramids is longer in *P. pedifera* than in *P. atrata* (Pls. 15, figs. *2, 3;* 27, *2, 3;* 28, figs. *2, 3*). The foramen formed by the apophyses and their hooklike appendages (Pl. 15, figs. *3, 4*) is much larger than in young specimens of *P. atrata* (Pl. 27, figs. *3, 4*), where it is rectangular; there are no hooks to the apophyses (Pl. 27, figs. *7, 8 a*) while they are well developed in older speci-

mens (Pl. 28, figs. *3, 4, 7 a, 8 a*) but do not compare in length with those of *P. pedifera* (Pl. 15, figs. *3, 4, 7 a, 9 a*). The compass is distinctly jointed in *P. pedifera* and in the young of *P. atrata* (Pls. 15, fig. *13;* 27, fig. *14*); in the old of *atrata* there is no trace of any suture. The differences in the braces are very slight.

In *Colobocentrotus Stimpsoni*, the pyramids are broader at the summit (Pl. 44, figs. *3, 4*) than the pyramids of the other species; the corrugations are coarser (Pl. 44, figs. *4, 5, 8 a, 9*); the apophysal foramen is wider than that of *P. pedifera*, and the hooks are intermediate in length between those of *P. pedifera* and *P. atrata*. The compass is jointed (Pl. 44, figs. *12 a, b*).

The auricles of a small specimen of *P. atrata*, 8 mm. in diameter, are not united (Pl. 26, figs. *9, 10*); they touch in a specimen of 14 mm. (Pl. 26, fig. *12*) and are connected in a specimen of 45 mm. (Pl. 26, fig. *13*). In a large specimen of *P. pedifera* 82 mm. in diameter they are closely connected (Pl. 14, figs. *5, 6*); the same is the case in a specimen of *Colobocentrotus Stimpsoni* of 88 mm. in diameter (Pl. 43, figs. *4, 5*).

The pores close to the actinal system show how the ambulacral plates gradually increase in number and become resorbed as they move into the base of the auricles both from the actinal and the abactinal sides (see Pls. 14, figs. *5, 6;* 26, figs. *12, 13;* 43, figs. *4, 5;* compare also Pl. 26, fig. *9* with Pl. 26, figs. *12, 13*). The youngest poriferous plates are still seen on Pl. 14, fig. *6*, and Pl. 43, fig. *4;* somewhat older plates are shown on Pl. 14, fig. *7*, which have been resorbed by the auricle (Pls. 14, fig. *5;* 26, fig. *13*); the upper part of the auricle in fig. *7*, Pl. 14, is cut off.

The Spicules of the Pedicels of Colobocentrotus and Podophora.

Pls. 16; 45.

A large number of pedicels of Colobocentrotus and Podophora have been examined (Pls. 16, 45). They all agreed in having a disk made up of four basal plates; the periphery of the plates is angularly lobed. The number of lobes varies from seven to thirteen. In *Colobocentrotus Stimpsoni* (Pl. 45, figs. *1, 2*) the plates have from twelve to thirteen lobes, while in the other species of the genus, *Colob. Mertensii*, the basal disks have usually not more than seven to nine lobes. See the figures of the disk of an actinal pedicel of *P. pedifera* (Pl. 16, figs. *1–7*), of *P. atrata* (Pl. 16, figs. *9–11, 13*) and of *Colob. Mertensii* (Pl. 45, fig. *7*). At the base of the basal disk on the lower

side is found a set of three or four layers of yoke-shaped spicules (Pls. 16, fig. *6;* 45, fig. *8*). In *P. pedifera* the yoke-shaped spicules are nearly straight (Pl. 16, fig. *8*), with a row of small perforations on the under side of the spicule. In *P. atrata* the yoke-shaped spicule is well arched (Pl. 16, fig. *12*) with but few larger perforations.

These perforations frequently pass into more or less prominent teeth (Pl. 45, figs. *4, 6*). The yoke-shaped spicules of *Colob. Stimpsoni* (Pl. 45, figs. *3–6*) and *Mertensii* (Pl. 45, figs. *8, 9*) have fewer perforations than those of *P. pedifera*, but more than those of *P. atrata*. The position of the layers of the yoke-shaped spicules with reference to the basal disks is well seen in Pl. 16, figs. *6, 9, 10*, and Pl. 45, fig. *8*. Fig. *14*, Pl. 16, and fig. *10*, Pl. 45, show the atrophied tip of an abactinal pedicel. No spicules were found in the tubes of the pedicels.

The changes due to growth in the appearance of the basal disk are shown in figs. *11* and *13*, Pl. 16; the former is the basal plate of the pedicel of a denuded specimen of *P. atrata* measuring 8 mm. in diameter, the other of a pedicel from a specimen measuring 45 mm. with spines.

The basal disks of the other species were taken from specimens varying between 70 and 88 mm. in diameter including the spines; *P. pedifera*, 82 mm.; *Colob. Mertensii*, 70 mm.; *Colob. Stimpsoni*, 88 mm.

The Pedicellariæ of Colobocentrotus and Podophora.

Plates 3ª; 4–6; 17–19; 29; 30.

The four kinds of pedicellariæ of *Podophora pedifera* are figured on Pl. 3ª, figs. *1–4*. The rods vary but little in length, but the length of the necks differs greatly. In the tridentate pedicellariæ (Pl. 3ª, fig. *1*) the neck is nearly twice as long as the rod; in the ophicephalous pedicellariæ (Pl. 3ª, fig. *2*) it is but slightly longer than the rod.

The heads of the triphyllous and globiferous pedicellariæ are small (Pl. 3ª, figs. *3, 4*), that of the triphyllous pedicellariæ being scarcely wider than the neck; this is about twice the length of the rod (Pl. 3ª, fig. *3*), while the neck of the globiferous pedicellariæ is reduced to a minimum, the valves seeming to rest upon the head of the rod (Pl. 3ª, fig. *4*).

The heads of the tridentate pedicellariæ of *Podophora atrata* seem to be somewhat more elongated and pointed (Pl. 3ª, fig. *5*) than those of *P. pedifera*, and have a much shorter neck. The ophicephalous pedicellariæ

(Pl. 3ª, fig. *6*) have a comparatively smaller head and longer neck. The triphyllous pedicellariæ (Pl. 3ª, fig. 7) are slightly larger, and the globiferous pedicellariæ (Pl. 3ª, fig. *8*) larger than those of *P. pedifera*.

The tridentate pedicellariæ of *Colobocentrotus Mertensii* (Pl. 3ª, fig. *9*) are closely allied to those of *P. atrata*, as are also the ophicephalous ones (Pl. 3ª, fig. *11*). The triphyllous pedicellariæ (Pl. 3ª, fig. *10*) have a proportionally shorter neck and larger head than in the two species named above.

In the genus Podophora we find four kinds of pedicellariæ: the ophicephalous, tridentate, triphyllous, and globiferous. On Pls. 4–6 I have given figures of the valves of the four kinds taken from different parts of tests of *P. pedifera*. Their position is noted in the description of the Plates. The figures will give a far better idea of the characteristics of the pedicellariæ than any description I can give. Taking the figures of the valves of ophicephalous pedicellariæ of *P. pedifera* (Pls. 4, figs. *1–6; 11–17;* 6) one cannot fail to be struck with the asymmetry of the valves, the great variation in the size and arrangement of the foramina, in that of the hinges, of the serrations of the edges, to say nothing of the great variation in the size of the ophicephalous pedicellariæ which vary from .33 mm. to .61 mm. in length; we note such extremes in the shape and the ornamentation of the ophicephalous pedicellariæ of *P. pedifera* as those of Pl. 6 figs. *1, 2, 4, 9, 10, 12, 14, 16, 17*, taken from four individuals.

The valves of the globiferous pedicellariæ of the same species (Pls. 4, figs. *18–22;* 5, figs. *10–13*) taken from three specimens show equally great differences in shape, size, and ornamentation; they vary from .21 mm. to .37 mm. in length, and even of the triphyllous pedicellariæ figured (Pl. 5, figs. *7–9*) no two of the valves are alike.

We finally come to the tridentate pedicellariæ of *P. pedifera* (Pls. 4, figs. *7–10;* 5, figs. *1–6*) varying in length from .86 mm. to .99 mm. The figures are from pedicellariæ taken from five specimens, and they speak for themselves. No two are alike, either in shape, size, outline, or ornamentation.

The tridentate pedicellariæ of *P. atrata*, figured on Pls. 18, figs. *1–6, 13–16;* 19, figs. *1–13*, were taken from three specimens. The valves vary in length from .41 mm. to .90 mm. The blade of *P. atrata* is much more elongate than the blade of *P. pedifera*. The variation in the serration of the edge of the blade is very marked (compare Pl. 18, figs. *6, 15, 16* with the same

edge of Pl. 19, figs. *1*, *2*, *3*, *10*, *11*). In one case the serration is limited to a few large teeth, in the other the edge is serrated for the whole length of the blade. The size and arrangement of the foramina of the valve both of the basal part and of the blade also varies greatly. In many of the valves the base passes very gradually into the blade (Pl. 19, figs. *7–10*), in others the junction is sharply marked (Pl. 18, figs. *4*, *5*), and in others the outline of the base is quite irregular (Pl. 18, figs. *1–3*). It would be difficult to say which of these pedicellariæ are typical of *P. atrata;* as in *P. pedifera* the valves of the triphyllous pedicellariæ (Pls. 18, figs. *10–12;* 19, figs. *14–16*) vary greatly in outline and in ornamentation. The valves figured were taken from two specimens; they vary in length from .11 mm. to .16 mm.

Compared with the globiferous pedicellariæ of *P. pedifera*, though they vary greatly (Pls. 4, figs. *18–22;* 5, figs. *10–13*), those of *P. atrata* (Pl. 18, figs. *17*, *18*) do not show any important differences.

One of the ophicephalous pedicellariæ of *P. atrata* is figured on Pl. 18, figs. *7–9*. The edge of the valves is more finely serrated than in the majority of the ophicephalous pedicellariæ of *P. pedifera*, but some of them are fully as finely serrated as those of *P. atrata*.

Owing to the great variation in the valves, neither the ophicephalous pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. *1–6*, *10–13*, *16*), varying in length from .36 mm. to .51 mm., nor those of *Colob. Mertensii* (Pl. 30, figs. *1*, *2*, *9*, *12–15*), varying in length from .27 to .48 mm. show any character by which it would be possible to distinguish these two species, or to distinguish them in turn from *P. pedifera* or *P. atrata*. It is quite possible to select ophicephalous pedicellariæ of *P. pedifera* and *Colob. Stimpsoni* which are very similar, and which it would be difficult to distinguish (see Pl. 6, fig. *10* and Pl. 29, fig. *13*). The valves of the triphyllous pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. *14–15*) appear to be somewhat more slender than those of *Colob. Mertensii* (Pl. 30, figs. *10–11*, *16*), and the foramina of the valves of the triphyllous pedicellariæ of these two species are perhaps, on the whole, smaller than those of *P. pedifera* and *P. atrata*.

The tridentate pedicellariæ of *Colob. Stimpsoni* (Pl. 29, figs. *7–9*) and those of *Colob. Mertensii* (Pl. 30, figs. *3–8*) resemble more the general pattern of those of *P. pedifera*, but in this case also the difference in the ornamentation of the valves, in the proportions of the base to the blade makes it impossible to designate any one figure as a typical tridentate valve of either species.

The valves of the tridentate pedicellariæ of *Colob. Stimpsoni* vary in length from .78 mm. to .88 mm.; those of *Colob. Mertensii* from .41 to .81 mm.

The Cystacanths and Sphæridia of Colobocentrotus and Podophora.

Pls. 1–3; 31; 32.

A comparison of the sphæridia of the species of Colobocentrotus and Podophora shows at once how variable they are and how misleading their characters seem as guides to the affinities of the species of the genus. From a first glance at the figures of Pls. 31 and 32, we would arrange on one side the more or less cylindrical sphæridia of *P. pedifera* (Pl. 31, figs. *1–4*), and the three other species with globular sphæridia on the other. Yet no one would attempt to say that *P. atrata* is more closely allied to *Colob. Stimpsoni* and *Colob. Mertensii* than to *P. pedifera*, as would be legitimate from the sphæridia alone.

Pl. 13, fig. *5*, shows a line of sphæridia on the actinal part of the right ambulacral zone. The great variation which exists in the sphæridia of *P. atrata* is well seen on comparing the figures of sphæridia taken from different parts of the same individual (measuring 82 mm. in diameter, including the spines), viz., the left sphærid of Pl. 31, fig. *1*, the left of fig. *2*, the middle of fig. *3*, and the right of fig. *4*, taken respectively from the right posterior ambulacrum, the odd anterior ambulacrum, the left anterior ambulacrum, and the left posterior ambulacrum. They vary in length from .19 mm. to .34 mm., and in outline are cylindrical, elliptical, or club-shaped.

In *P. atrata* the variation in shape is not as marked (Pl. 31, figs. *5–8*), yet there are such extremes in shape as the right sphærid of Pl. 31, fig. *6*, and the right sphærid of Pl. 31, fig. *7*, the one measuring .20 mm., the other .25 mm. in length; both were taken from the same specimen of 65 mm. in diameter including the spines; the one from the odd anterior ambulacrum, the other from the left posterior ambulacrum.

One might think, on examining the figures of Plate 32, that the sphæridia of *Colob. Stimpsoni* and *Colob. Mertensii* differed but little if the comparison is made between such sphæridia as Pl. 32, figs. *1*, *4*, and Pl. 32, fig. *7*, and the central figure of fig. *5*. When we come to compare such extremes of *Colob. Stimpsoni* as Pl. 32, fig. *1*, with the extremes of *Colob. Mertensii* (Pl. 32, fig. *6*), the differences are most striking; while a comparison of the left figure of Pl. 32, fig. *7* (*Colob. Mertensii*) with the left figure of Pl. 32, fig. *3* (*Colob.*

Stimpsoni) would show that they are specifically identical; again such sphæridia of *Colob. Stimpsoni* (Pl. 32, fig. *4*, right-hand figure) and the third figure of Pl. 32, fig. *6* (*Colob. Mertensii*) should leave no doubt of their specific difference.

The sphæridia of *Colob. Stimpsoni* were taken from the left posterior and the left anterior ambulacra of a specimen measuring 88 mm. in diameter, and those of *Colob. Mertensii* from the odd anterior and the left anterior ambulacrum of a specimen measuring 77 mm. in diameter including the spines, the sphæridia varying in length from .23 to .27 mm.

The great variation in the shape of the sphæridia and of the pedicellariæ, depending in great measure on the position they occupy, does not seem to make these organs important factors in the ultimate classification of Echini, as has been maintained by some recent writers. At any rate, in the genera Colobocentrotus and Podophora we have no basis, from the data obtained by the examination of the pedicellariæ, upon which to build the identification of the species of this genus. We are led to the belief that while their examination is certainly most interesting and instructive as far as the general groups of Echini are concerned, the application of the special details they furnish can only bring about endless confusion when applied to the classification of the genera and species of Echini, not only to the exclusion of other characters, but also when given an inordinate importance in connection with other structural features of the group.

While examining some specimens of *P. pedifera* Mr. M. Westergren observed in the median line of the actinal part of one of the ambulacra peculiar organs, a group of which has been figured on Pl. 1, fig. *1*. They might at first sight be taken for clusters of poison glands of some globiferous pedicellariæ. These organs are small, the sacs with the spine rarely measuring more than one millimeter in length. Five or six are found on the actinal side of each ambulacrum (Pl. 1, fig. *1*). They consist in *P. pedifera* of three spherical sacs surrounded by an envelope (Pl. 1, figs. *3*, *4*). Each sac has a pore which in the smaller organs has a more or less pentagonal shape. The larger sacs seem when expanded to have forced out one or more transparent bladders (Pl. 1, figs. *2-4*). I could not detect any spicules or other calcareous deposits in any of these diminutive organs which we may call cystacanths. Only one of the sacs is attached to the extremity of a minute spine, greatly resembling the rods of pedicellariæ.

On Pl. 1 are given a number of figures showing the cystacanths of *P. pedifera*

from different sides. They are drawn from a dried specimen, the sacs having been treated with alcohol and glycerine. The cystacanths of *P. atrata* differ greatly from those of *P. pedifera*. The sacs are more closely compressed, forming a club at the top of the rod (Pl. 2, figs. *1–3*). The bladders contained in the sacs are much thicker than those of *P. pedifera*. The sacs are also irregularly dotted with black spots. The cystacanths of *P. atrata* are found on the abactinal extremity of the ambulacrum, close to the ocular plates, and are absent from the actinal side. Pl. 1, figs. *1*, *2* are drawn from an alcoholic specimen.

In *Colob. Stimpsoni* the cystacanths are comparatively larger (Pl. 2, figs. *4–7*), but coming from a dried specimen they have lost their globular shape and the existence of pores could not be traced. The sacs seem tougher than those of *P. pedifera*. In one of the figures (Pl. 2, fig. *5*) a few spicules could be detected.

The cystacanths of *Colob. Mertensii* (Pl. 2, figs. *8-12*) are elongate, resembling more those of *Colob. Stimpsoni*. They showed no pores. The spines of the cystacanths (figs. *11*, *12*) resemble those of tridentate pedicellariæ (Pl. 2, fig. *13*) but they expand somewhat more at the tip.

In *Chætodiadema pallidum* A. Ag. and Clark, cystacanths (Pl. 3) are found only around the abactinal system, mainly upon the interambulacral plates. They apparently vary far more in shape than in the species of Colobocentrotus and Podophora. The cystacanths of Pl. 3, figs. *5*, *6*, *7*, *8* are somewhat club shaped like those of *P. atrata*. They show well developed pores (Pl. 3, figs. *2*, *3*, *5*, *7*, *11*). Others (Pl. 3, fig. *1*) look more like the wrinkled sacs of the cystacanths of *Colob. Stimpsoni*. Others again consist only of a single elongated sac (Pl. 3, figs. *2*, *9*). Transparent bladders like those seen in *P. pedifera* are seen on Pl. 3, figs. *1*, *2*, *11*. It will be interesting to see if cystacanths are found in other echini and to obtain, if possible, some clue to the function of these problematical organs which suggest affinities both to the poison glands of globiferous pedicellariæ and to the sac-carrying spines of Echinothuriae.

On Pl. 12, figs. *8–10* of the Ingolf Ex. Echini, Dr. Mortensen gives sections of an organ which remind one of cystacanths, but he calls them globiferous pedicellariæ, though they seem to be without valves or other calcareous deposits. He gives no further explanation of their structure in describing the globiferous pedicellariæ of *Haplos. pellucidum*.

Cystacanths vary greatly in number in different specimens, and their occur-

rence is not limited to the ambulacra near the sphæridia, nor are they limited to the ambulacra. They are found both in the ambulacral and interambulacral areas and on the actinal as well as the abactinal sides.

I can only offer suggestions as to the nature of the cystacanths. I have no observations of any value regarding their function. They may be modified sac-bearing spines such as are found among the Echinothuriæ or modified pedicellariæ in which the glands have developed into the glands of the cystacanths at the expense of the valves.

EXPLANATION OF THE PLATES.

PLATE 1.

Plate 1.

1–12. Podophora pedifera Agass.

1–11. Cystacanths from a specimen 82 mm. in diameter, including the spines.

1. Left posterior ambulacrum, actinal side, showing a group of cystacanths.
2. Expanded cystacanth, 0.92 mm.
3. Side view, of another specimen, 0.92 mm.
4. Seen from above, specimen of 0.90 mm.
5. Less developed with only three cysts, 0.66 mm.
6. Another stage with three cysts, 0.60 mm.
7. Showing the mode of attachment of the cysts to the spine, 0.71 mm.
8. Profile of cystacanth of 0.54 mm.
9. Same, front view.
10. Side view of one of the smallest cystacanths with three cysts, 0.41 mm.
11. The same, rear view.
12. Pedicellaria, to show its comparative size to the cystacanths.

All the figures equally magnified, measurements indicate the natural size of the sacs without the spine.

A.M. Vietmeyer del. H. Mundy lith.

PLATE 2.

Plate 2.

1–3. **Podophora atrata Agass.**

1–3. Cystacanths from the abactinal side of a specimen 65 mm. in diameter, including the spines.

1. From the left posterior ambulacrum, near the ocular plate, front view, 0.37 mm.
2. In the same ambulacrum, but less expanded, 0.39 mm.
3. Profile, from the same ambulacrum, 0.29 mm.

4–7. **Colobocentrotus Stimpsoni A. Ag.**

4–7. Cystacanths from a specimen of 88 mm. diameter with spines.

4. Shows the attachment of the spine to the third lobe, 0.94 mm. from the left anterior ambulacrum, actinal side.
5. Front view of a cystacanth 0.60 mm. from the right anterior ambulacrum.
6. Same view of a cystacanth 0.58 mm. from the left posterior ambulacrum.
7. Profile of a cystacanth 0.70 mm. near the ambitus, from the right posterior ambulacrum.

8–13. **Colobocentrotus Mertensii Brandt.**

8–13. Cystacanths from a specimen 70 mm. in diameter including spines.

8. Contracted, with spine, 1.15 mm. close to the ambitus, from the odd anterior ambulacrum.
9. Rear view, 0.44 mm. from the left anterior ambulacrum.
10. Seen from beneath, 0.59 mm. near the ambitus, from the left anterior ambulacrum.
11. Spine of a cystacanth.
12. Upper end of same, somewhat more magnified.
13. Spine of a pedicellaria.

All the figures are equally magnified; measurements indicate the natural size of the sacs without spine.

PLATE 3.

Plate 3.

1–11. **Chaetodiadema pallidum** A. Ag. and Cl.

1–11. Cystacanths, from the abactinal side of the amubulacral and interambulacral plates round the summit of a specimen 55 mm. in diameter.

1. Front view of a somewhat contracted double cyst, 1 mm.
2. Single cyst, 1.30 mm. magnification of the drawing reduced one half.
3. Expanded, showing the pavement of epithelial cells and the two pores, 0.73 mm.
4. Shows a line of glands, 0.61 mm.
5. Cystacanth with epithelial cells, 0.66 mm.
6. Profile, showing a string of glands, 0.60 mm.
7. Front view with pores, 0.53 mm.
8. Cystacanths similar in form to fig. 7, 0.56 mm.
9. Profile of a cystacanth, 0.73 mm.
10. Younger stage, 0.55 mm.
11. Similar to fig. 10 with large pores, 0.36 mm.

The figures are equally magnified except 2; measurements give the natural size of the cyst with its spine.

"Albatross" Ex. 1902. Station 4104.

PLATE 3a.

Plate 3a.

1–4. **Podophora pedifera** Agass.

From a specimen 74 mm. in diameter, including the spines.

1. Tridentate pedicellaria. 3.9 mm.
2. Ophicephalous pedicellaria. 2.9 mm.
3. Triphyllous pedicellaria. 2.2 mm.
4. Globiferous pedicellaria. 1.4 mm.

5–8. **Podophora atrata** Agass.

From a specimen 68 mm. in diameter, including the spines.

5. Tridentate pedicellaria. 2.1 mm.
6. Ophicephalous pedicellaria. 1.5 mm.
7. Triphyllous pedicellaria. 1.2 mm.
8. Globiferous pedicellaria. 1.4 mm.

9–11. **Colobocentrotus Mertensii** Brandt.

From a specimen 72 mm. in diameter, including the spines.

9. Tridentate pedicellaria. 2.7 mm.
10. Ophicephalous pedicellaria. 1.9 mm.
11. Triphyllous pedicellaria. 2.7 mm.

All the figures are of relative sizes and under the same enlargement; the measurements indicate the greatest length of the pedicellariæ in the positions in which they are drawn.

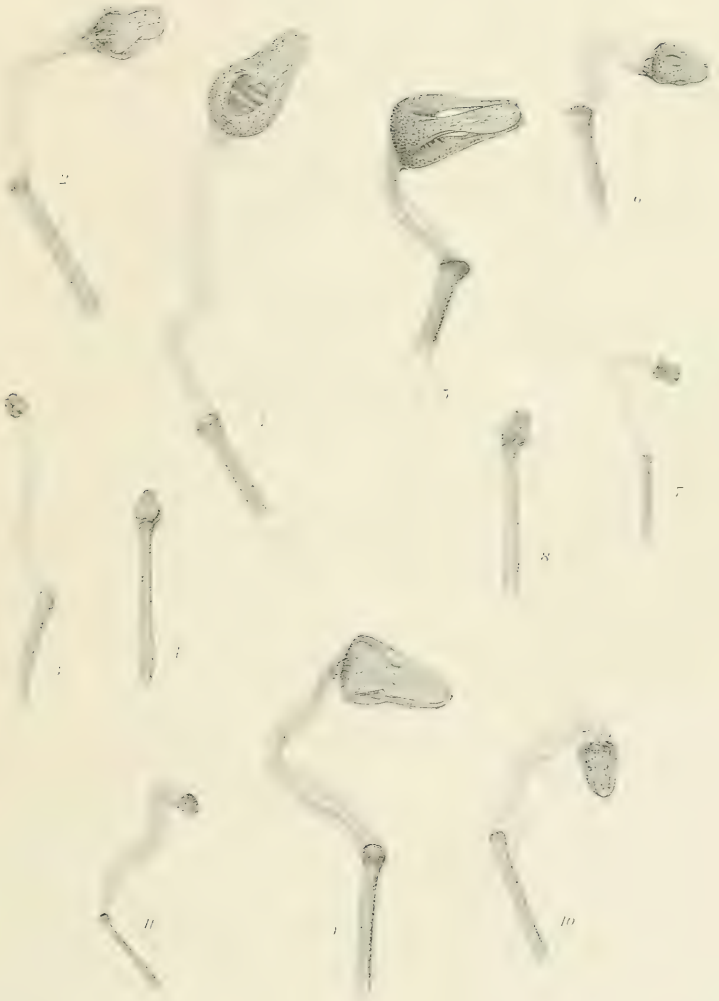


PLATE 4.

Plate 4.

1–22. Podophora pedifera Agass.

1–22. Valves of Pedicellariæ.

1. Valve of an Ophicephalous pedicellaria, in profile, from the buccal membrane near the teeth.
2. Valve of an Ophicephalous pedicellaria, another view of the same (fig. 1).
3. Valve of an Ophicephalous pedicellaria, interior of a valve of the same.
4. Valve of an Ophicephalous pedicellaria, similar to 3; exterior view.
5. Valve of an Ophicephalous pedicellaria, interior view of same.
6. Valve of an Ophicephalous pedicellaria, profile of same.
7. Valve of an Tridentate pedicellaria, from the right anterior ambulacrum, not far from the actinal system.
8. Valve of a Tridentate pedicellaria, the same as 7; external view.
9. Valve of a Tridentate pedicellaria, the same as 7; internal view.
10. Valve of a Tridentate pedicellaria, the same as 7; profile of the articulation.
11. Valve of an Ophicephalous pedicellaria, from the left anterior ambulacrum, nearer the ambitus than to the actinal system.

12, 13, 14. Details of the same pedicellaria as 11; articulations of each valve.

15. Valve of an Ophicephalous pedicellaria, from the left posterior interambulacrum, midway between the actinal system and the ambitus.
16. Serration from same as 15.
17. Stalk and head of an Ophicephalous pedicellaria.
18. Valve of a Globiferous pedicellaria, from the apical part of the left anterior ambulacrum.
19. Detail of an articulation seen from the exterior, the same as 18.
20. Interior the same as 18.
21. Exterior the same as 18.
22. View of the stalk and head of a globiferous pedicellaria.

The figures are about equally enlarged with the exception of 1–6, which are somewhat larger.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

PLATE 5.

Plate 5.

1-13. Podophora pedifera Agass.

1-13. Valves of Pedicellariæ, seen from the exterior.

1. A valve of a Tridentate pedicellaria, 0.86 mm. from the left anterior ambulacrum, near the actinal system of a specimen 73 mm. in diameter.
2. A valve of a Tridentate pedicellaria, 0.91 mm. from the left anterior ambulacrum, close to the actinal system of a specimen 75 mm. in diameter.
3. A valve of a Tridentate pedicellaria, 0.94 mm. from the left posterior interambulacrum, close to the actinal system, from the same specimen as 2.
4. A valve of a Tridentate pedicellaria, 0.98 mm. from the right anterior interambulacrum, near the actinal system of a specimen 77 mm. in diameter.
5. A valve of a Tridentate pedicellaria, 0.99 mm. from the left anterior ambulacrum, close to the actinal system of a specimen 80 mm. in diameter.
6. A valve of a Tridentate pedicellaria, 0.94 mm. from the right anterior ambulacrum midway between the actinal system and the ambitus, from a specimen 82 mm.in diameter.
7. A valve of a Triphyllous pedicellaria, 0.13 mm. from the right posterior ambulacrum, at the ambitus, from a specimen 68 mm. in diameter.
8. A valve of a Triphyllous pedicellaria, 0.14 mm. from the odd anterior ambulacrum, near the actinal system of the same specimen as 7.
9. A valve of a Triphyllous pedicellaria, 0.13 mm. from the left posterior ambulacrum, midway between the actinal system and the ambitus of the same specimen as 7.
10. A valve of a Globiferous pedicellaria, 0.22 mm. from the odd anterior ambulacrum, near the apical system, from a specimen 72 mm. in diameter.
11. A valve of a Globiferous pedicellaria, 0.37 mm. from the right posterior ambulacrum near the actinal system of the same specimen as 10.
12. A valve of a Globiferous pedicellaria, 0.22 mm. from the odd anterior ambulacrum, nearer the ambitus than the abactinal system, from a specimen 74 mm. in diameter.
13. A valve of a Globiferous pedicellaria, 0.21 mm. from the odd anterior ambulacrum, midway between the ambitus and the abactinal system, from a specimen 83 mm. in diameter.

The measurements of the diameter of the specimens include the spines. The dimensions given of the pedicellariæ are natural size. The corresponding valve was selected for each figure.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

PLATE 6.

Plate 6.

1-17. Podophora pedifera Agass.

1-17. Exterior views of valves of Ophicephalous pedicellariæ.

1. A valve 0.35 mm. adjoining the teeth, from a specimen 73 mm. in diameter.
2. A valve 0.44 mm. adjoining the teeth, from a specimen 75 mm. in diameter.
3. A valve 0.36 mm. adjoining the teeth, from a specimen 82 mm. in diameter.
4. A valve 0.53 mm. from the right posterior ambulacrum, near the ambitus, of a specimen 68 mm. in diameter.
5. A valve 0.59 mm. from the right anterior ambulacrum, midway between the actinal system and the ambitus of the same specimen as 4.
6. A valve 0.55 mm. from the left anterior ambulacrum, near the actinal system of the same specimen as 4.
7. A valve 0.57 mm. from the right posterior interambulacrum, near the actinal system of a specimen 72 mm. in diameter.
8. A valve 0.59 mm. from the left anterior interambulacrum, near the actinal system of the same specimen as 7.
9. A valve 0.57 mm. from the right anterior ambulacrum, midway between the actinal system and the ambitus of a specimen 73 mm. in diameter.
10. A valve 0.48 mm. from the right anterior ambulacrum, at the ambitus of a specimen 75 mm. in diameter.
11. A valve 0.59 mm. from the odd anterior ambulacrum, midway between the actinal system and the ambitus, of the same specimen as 10.
12. A valve 0.61 mm. from the odd posterior interambulacrum, near the ambitus, of the same specimen as 10.
13. A valve 0.57 mm. from the odd posterior interambulacrum, near the actinal system of a specimen 77 mm. in diameter.
14. A valve 0.54 mm. from the left anterior interambulacrum, at the ambitus of a specimen 82 mm. in diameter.
15. A valve 0.56 mm. from the right posterior ambulacrum, midway between the actinal system and the ambitus of a specimen 85 mm. in diameter.
16. A valve 0.48 mm. from the odd posterior interambulacrum at the ambitus of the same specimen as 15.
17. A valve 0.38 mm. from the left posterior interambulacrum at the ambitus of the same specimen as 15.

The measurements of the diameter of the test include the spines, with the exception of 1, 2, 4, 5, 6, 14, and 15, which are denuded. The corresponding valve was selected for each figure. The figures are about equally magnified with the exception of 1–3, which are somewhat larger. The dimensions given of the valves of the pedicellariæ are natural size.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

A.M. Westerman del.

PLATE 7.

Plate 7.

1-3. Podophora pedifera Agass.

1. Seen from the actinal side.
2. The same specimen seen from the abactinal side.
3. The same specimen seen in profile, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1 and 2.

All figures are natural size.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

Plate 8.

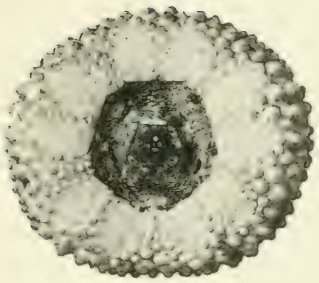
1–3. Podophora pedifera Agass.

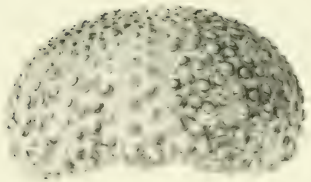
1. Denuded test, seen from the actinal side.
2. The same specimen seen from the abactinal side.
3. The same specimen seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.





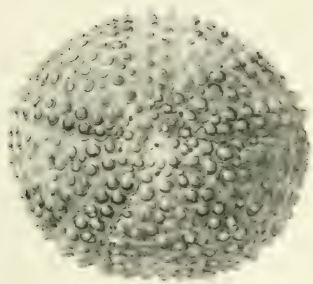


PLATE 9.

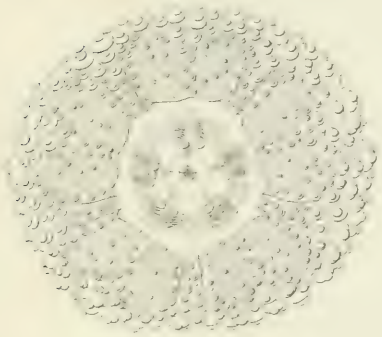
Plate 9.

1–6. Podophora pedifera Agass.

1. Denuded test, seen from the actinal side, measuring 55 mm. in diameter.
2. The same, from the abactinal side.
3. The same in profile, facing the odd anterior ambulacrum.
4. Actinal side of a specimen measuring 82 mm. in diameter, including the spines.
5. The same specimen seen from the abactinal side.
6. The same specimen seen facing the odd posterior interambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2, 4, 5.
Outer reef, Fakarava Paumotus, "Albatross" Ex., 1899–1900.

1



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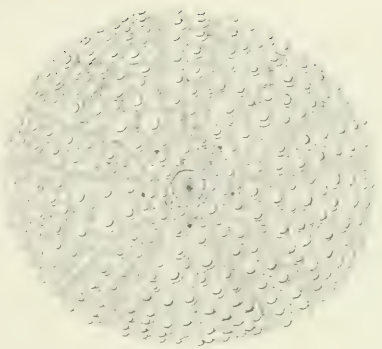

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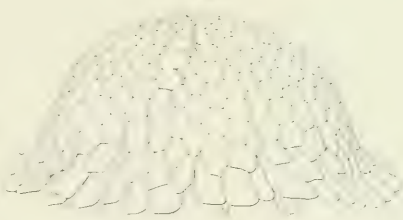

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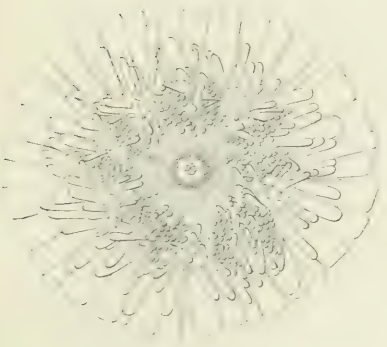

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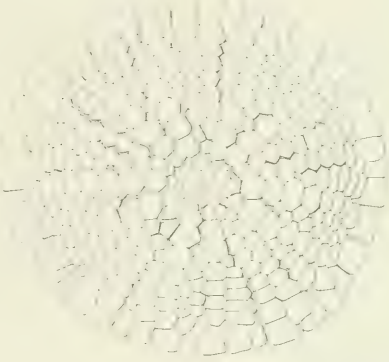


A.M. Vissering del.

H. Meyer lith.

PLATE 10.

Plate 10.

1-6. Podophora pedifera Agass.

1. Odd posterior interambulacrum, and left posterior with part of right posterior ambulacrum, showing the grouping of the spines of a specimen measuring 75 mm. in diameter, including the spines.
2. The same portion of the test as in 1 of a specimen, 76 mm. in diameter.
3. The same portion of the test as in 1 of a specimen 77 mm. in diameter.
4. The same portion of the test as in 1 of a specimen 80 mm. in diameter.
5. The same portion of the test as in 1 of a specimen 82 mm. in diameter.
6. The same portion of the test as in 1 of a specimen 87 mm. in diameter.

The dotted lines unite the primary radioles belonging to the same vertical row.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899-1900.

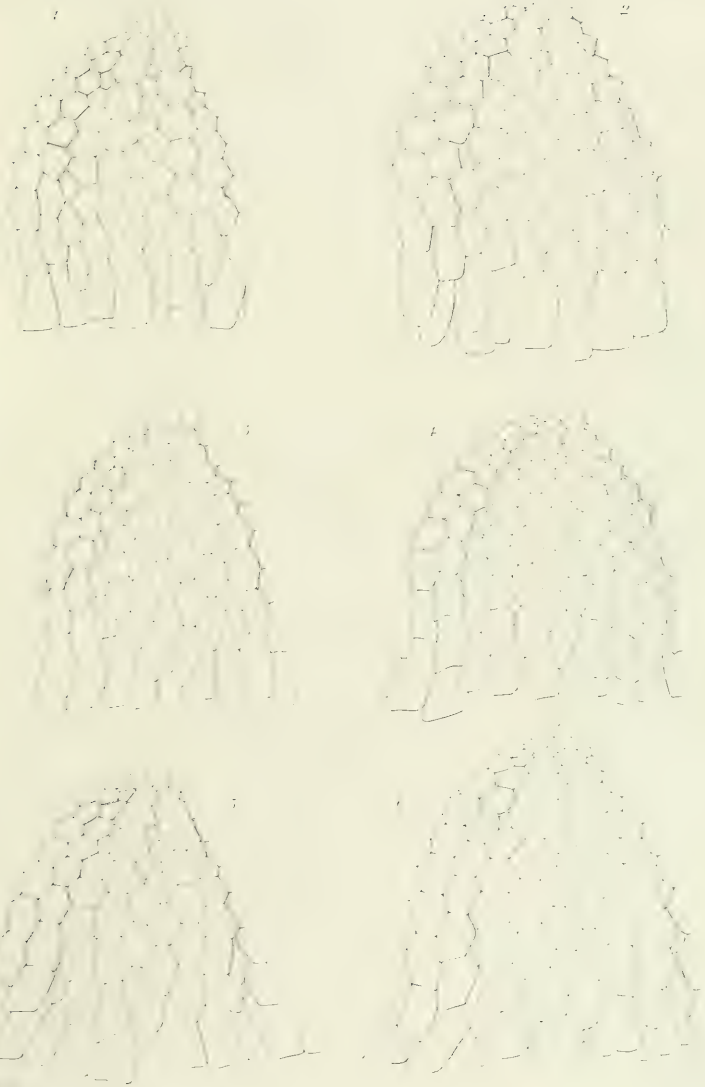


Plate 11.

1–48. Podophora pedifera Agass.

1–48. Spines, from a specimen 82 mm. in diameter.

1. Spines seen in profile, taken from the left posterior ambulacrum towards the apical system.
2. Spine, from a poriferous plate of the buccal membrane.
3. Spine, from the first plate at the actinal system of the odd anterior ambulacrum.
4. Spine, from the second plate, of the left anterior interambulacrum.
5. Spine, from the third plate, of the left anterior interambulacrum.
6. Spine, from the third plate, in the odd anterior ambulacrum.
7. The profile of the same spine as 6.
8. Spine, from the fourth plate of the left anterior ambulacrum.
9. Spine, { upper surface
10. Spine, { lower surface } from the fourth plate of the odd anterior ambulacrum.
11. Spine, lower surface } at the ambitus.
12. Spine, upper surface } from the fifth plate of the odd anterior ambulacrum.
13. Spine, profile } these larger radioles vary in length from 15 18 mm.
14. Spine, lower surface
15. Spine, upper surface } from the sixth plate of the odd anterior ambulacrum.
16. Spine, profile
17. Spine, lower surface } from the seventh plate of the odd anterior ambulacrum.
18. Spine, upper surface
19. Spine, lower surface
20. Spine, upper surface } from the eighth plate of the odd anterior ambulacrum.
21. Spine, profile
22. Spine, lower surface
23. Spine, top view } from the tenth plate of the left anterior interambulacrum.
24. Spine, profile
25. Spine, lower surface
26. Spine, top view } from the eleventh plate of the left anterior interambulacrum.
27. Spine, profile
28. Spine, lower surface
29. Spine, top view } from the twelfth plate of the odd anterior ambulacrum.
30. Spine, profile
31. Spine, lower surface
32. Spine, upper surface } from the thirteenth plate of the odd anterior ambulacrum.
33. Spine, profile

The plates from which the spine is taken are counted from the actinal system.

34. Spine, lower surface
35. Spine, upper surface } from the ocular and genital plates.
36. Spine, profile

37. Spine, lower surface
38. Spine, upper surface
39. Spine, profile

} from the ocular and genital plates.

40. Spine, lower surface
41. Spine, upper surface

} from the ocular and genital plates.

42. Spine, side view
43. Spine, top view

} from the ocular and genital plates.

44. Spine, lower surface
45. Spine, top view

} from the ocular and genital plates.

46. Spine,
47. Spine,
48. Spine,

} spines, hidden by the big radioles, as seen in fig. 1.

The figures are about equally magnified except 2, 3, 5, 8, and 46, which are enlargements of adjoining figures in outline. The largest radioles at the ambitus measure 15–18 mm. in length.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

PLATE 12.

Plate 12.

1–6. **Podophora pedifera** Agass.

1. Left anterior interambulacrum.
2. The ninth and tenth interabulacral plates from the actinal system.
3. A tubercle, at the ambitus, from the seventh plate from the actinal system of the left posterior interambulacrum.
4. The same tubercle, seen in profile.
5. Shows a group of miliaries, from the left anterior interambulacrum, abactinal side, eleventh plate from the actinal system.
6. A genital plate and adjoining madreporite from the left anterior interambulacrum.

All the figures are taken from a denuded specimen, measuring 55 mm. in diameter. Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

PLATE 13.

Plate 13.

1–8. **Podophora pedifera** Agass.

1. Interior view of the actinal side, with the lantern in place, odd ambulacrum at the top.
2. A pair of poriferous plates of the buccal membrane, facing the odd anterior ambulacrum.
3. Exterior view of the odd anterior ambulacrum, at edge of the actinal system.
4. The same as 3, seen from the interior.
5. Right posterior ambulacrum, close to the actinal system, showing the sphæridia.
6. Fifth plate from the abactinal system of the odd anterior ambulacrum, abactinal side, exterior view, showing the arrangement of the pores.
7. Same as 6, interior view.
8. Ocular and abactinal ambulacral plates of the left posterior ambulacrum, seen from the interior.

The figures are from same individual: 82 mm. in diameter, including the spines.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

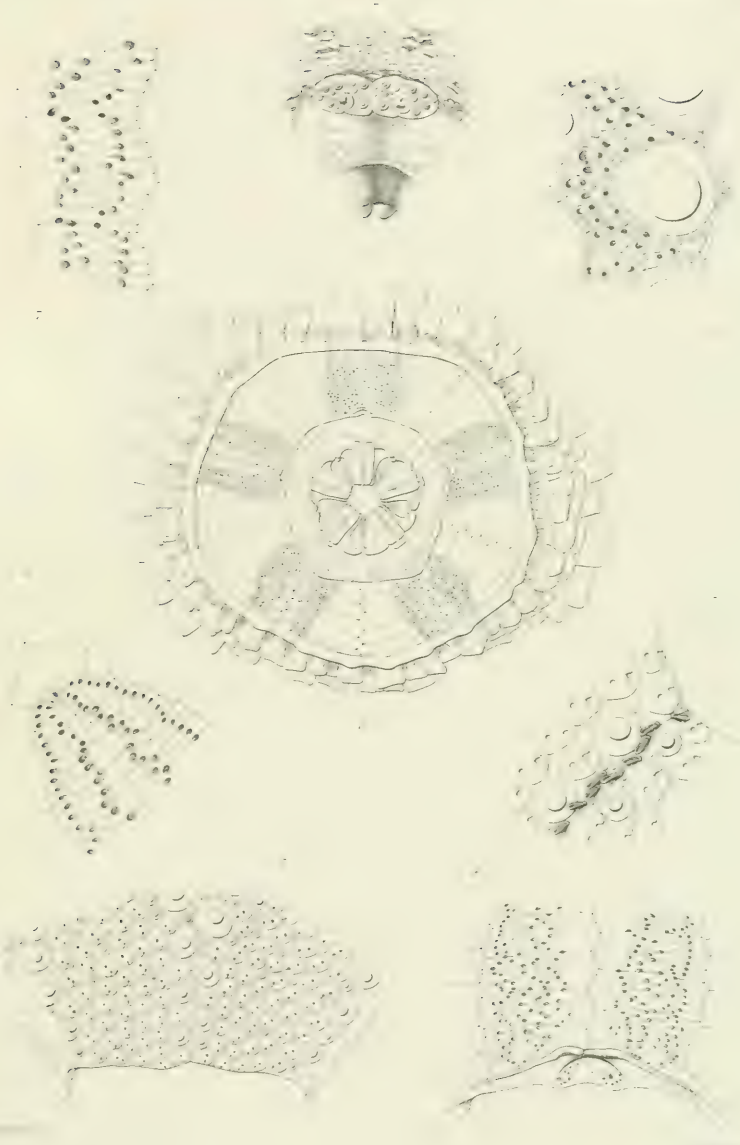


PLATE 14.

Plate 14.

1–9. **Podophora pedifera** Agass.

1. Abactinal system covered with spines, of a specimen measuring 81 mm. in diameter.
2. Abactinal system of another specimen, 82 mm. in diameter, denuded of its large spines.
3. Exterior view of the abactinal system, denuded, showing the madreporite, genital pores and anal system.
4. The same as 3, seen from the interior.
5. Auricles of the left anterior ambulacrum, seen looking towards the actinostome.
6. Auricles of left anterior ambulacrum, seen from the interior of the test.
7. Odd anterior ambulacrum adjoining the actinal system, seen from the interior, the auricles having been removed.
8. Interior view of the interradial plates adjoining the actinal system of the right anterior interambulacrum, showing the primordial plate.
9. The same as 8, of the odd posterior interambulacrum.

Figures 2 to 9 are drawn from the same individual, measuring 82 mm. in diameter, including the spines.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

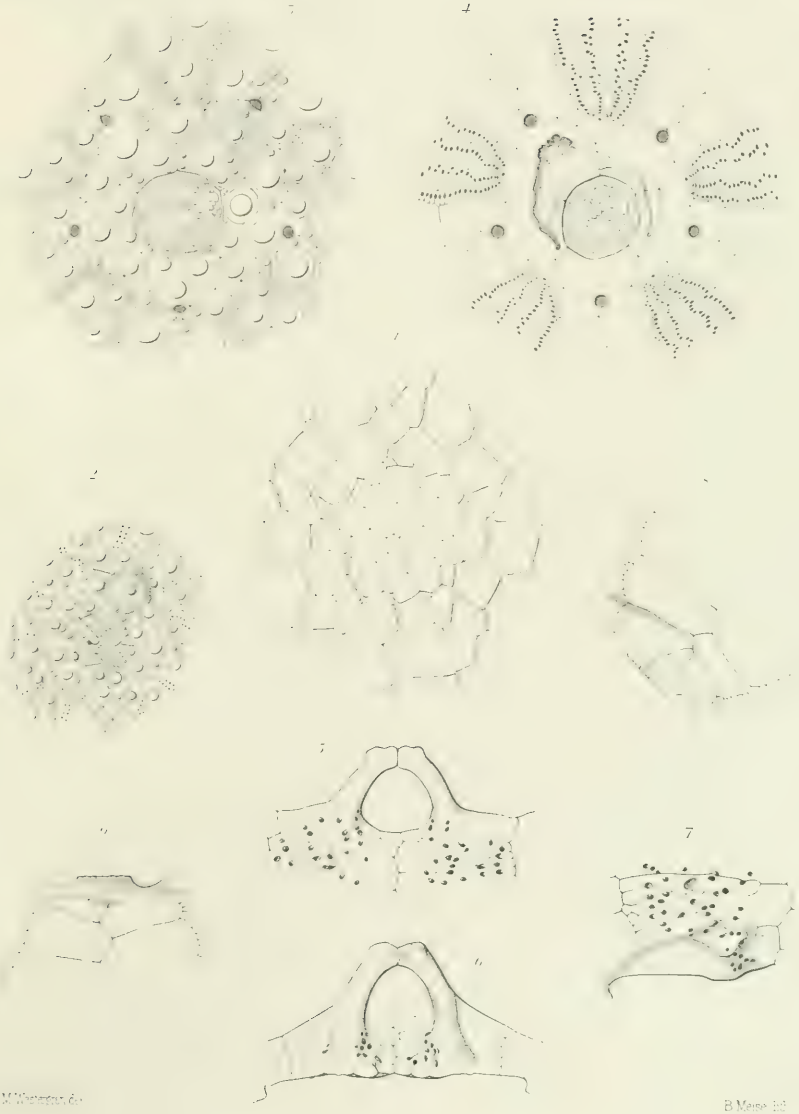


PLATE 15.

Plate 15.

1–13. **Podophora pedifera** Agass.

1. Lantern seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids seen from the exterior.
4. The same as 3, seen from the interior.
5. The same, seen in profile.
6. The same, seen from above.
7. a. Epiphysis of pyramid, seen from the interior, b. pyramid, in profile, seen from the interior.
8. Detail of the corrugation on the edge of the inside wall of a pyramid.
9. a. Epiphysis of pyramid, seen from the exterior, b. pyramid in profile, seen from the interior.
10. Upper end of a pyramid, exterior view showing a foramen.
11. a. Grooved tooth, b. dorsal view, c. seen in profile.
12. The brace, a. seen from above, b. same in profile, c. from below, d. endwise.
13. Compass, a. seen from above, b. the same in profile.

All the figures from a specimen measuring 82 mm. in diameter, including the spines.

Outer reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

PLATE 16.

Plate 16.

1-8. **Podophora pedifera** Agass.

1. The disk of an actinal pedicel, seen from above.
2. The same, seen from below.
3. Profile of the same.
4. Disk of an actinal pedicel, oblique view.
5. The disk of an actinal pedicel.
6. Central space of the disk of a pedicel, seen from below with yoke-shaped spicules.
7. Basal part of one of the laminæ.
8. Spicule.

9-14. **Podophora atrata** Agass.

9. An actinal pedicel, seen from below the disk.
10. Actinal pedicel seen in profile.
11. Basal part of one of the laminæ of the disk, from a specimen of 8 mm. in diameter.
12. Yoke-shaped spicule from the same specimen as 11.
13. Basal part of one of the laminæ of the disk.
14. The tip of a dorsal pedicel.

The figures 1 to 8 are from a specimen of 82 mm. in diameter including the spines. With the exception of 11, 12, the others are drawn from a specimen measuring 74 mm. in diameter, including the spines.

Podophora pedifera from the outside reef, Fakarava, Paumotus, "Albatross" Ex., 1899–1900.

P. atrata from the Hawaiian Ids., A. Garrett Coll.

Plate 17.

1-19. **Podophora atrata** Agass.

1–19. Valves of pedicellariæ.

1. A valve 0.23 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth.
2. A valve 0.19 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view.
3. A valve 0.22 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, profile.
4. A valve 0.22 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, detail of articulation, exterior view.
5. A valve 0.23 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, detail of articulation, exterior view.

Valves from the same pedicellaria.

6. A valve 0.40 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view.
7. A valve 0.32 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, interior view.
8. A valve 0.40 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 6.
9. A valve 0.36 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 7.
10. A valve 0.32 mm. Ophicephalous pedicellaria, from the buccal membrane close to the teeth, exterior view, magnified base of fig. 7.
11. A valve 0.47 mm. Tridentate pedicellaria, from the actinal side of the left anterior ambulacrum.
12. A valve 0.44 mm. Tridentate pedicellaria, interior view from the right anterior ambulacrum.
13. A valve 0.47 mm. Tridentate pedicellaria, exterior view, profile, from the right anterior ambulacrum.
14. A valve 0.47 mm. Tridentate pedicellaria, interior view, profile, from the right anterior ambulacrum.

From the same pedicellaria.

15. A valve 0.26 mm. Ophicephalous pedicellaria, near the ambitus from the actinal side of the right posterior interambulacrum.
16. A valve 0.26 mm. Ophicephalous pedicellaria, serration of edge, same pedicellaria as 15.
17. A valve 0.24 mm. Ophicephalous pedicellaria, interior view from the abactinal side of the right posterior interambulacrum.
18. A valve 0.11 mm. Globiferous pedicellaria, exterior view from the abactinal side of the left posterior ambulacrum.
19. A valve 0.11 mm. Globiferous pedicellaria, profile, same pedicellaria as 18.

Figures 1–5 are the same pedicellaria, from a specimen 8 mm. in diameter; 6–10, from a specimen 74 mm. in diameter; and 11–19 from a specimen 8 mm. in diameter, including the spines.

The measurements give the natural size. The enlargement of the figures is about the same, excepting 6, 7, and 8, 9, 10, which are somewhat larger.

Hawaiian Ids., A. Garrett, Coll.

PLATE 18.

Plate 18.

1-18. **Podophora atrata** Agass.

1–18. Valves of pedicellariæ.

1. A valve 0.67 mm. Tridentate pedicellaria, from the buccal membrane close to the teeth, exterior view.
2. A valve 0.65 mm. Tridentate pedicellaria, from the buccal membrane close to the teeth, exterior view.
3. A valve 0.63 mm. Tridentate pedicellaria, from the buccal membrane close to the teeth, interior view
4. A valve 0.85 mm. Tridentate pedicellaria, from the left anterior ambulacrum, not far from actinal system, exterior view.
5. A valve 0.88 mm. Tridentate pedicellaria, from the left anterior ambulacrum, interior view.
6. A valve 0.87 mm. Tridentate pedicellaria, from the left anterior ambulacrum, interior view profile.
7. A valve 0.57 mm. Ophicephalous pedicellaria from the right anterior ambulacrum 1, midway between the actinal system and the ambitus, interior view.
8. A valve 0.50 mm. Ophicephalous pedicellaria, same pedicellaria as 7, interior view.
9. A valve 0.48 mm. Ophicephalous pedicellaria, same pedicellaria as 7, interior view.
10. A valve 0.15 mm. Triphyllous pedicellaria, from the odd anterior ambulacrum among the sphæridia, exterior view.
11. A valve 0.15 mm. Triphyllous pedicellaria, same pedicellaria as 10, interior view.
12. A valve 0.16 mm. Triphyllous pedicellaria, same pedicellaria as 10, exterior view, profile.
13. A valve 0.49 mm. Tridentate pedicellaria, from the actinal side of the left anterior interambulacrum, near the ambitus, exterior view.
14. A valve 0.47 mm. Tridentate pedicellaria, same as 13, interior view.
15. A valve 0.48 mm. Tridentate pedicellaria, same as 13, exterior view, profile.
16. A valve 0.39 mm. Tridentate pedicellaria, from the right anterior ambulacrum, midway between the ambitus and the abactinal system, interior view.
17. A valve 0.24 mm. Globiferous pedicellaria from the odd anterior ambulacrum near the ocular plate, interior view.
18. A valve 0.21 mm. Globiferous pedicellaria, same as 17, exterior view, profile.

The valves are taken from the same specimen, measuring 74 mm. in diameter, including the spines.

The measurement of the figures gives the natural size; the enlargement of the valves of each pedicellaria is the same, but the enlargement of the different pedicellariæ is not identical.

Hawaiian Ids., A. Garrett Coll.

PLATE 19.

Plate 19.

1-16. Podophora atrata Agass.

1–16. Valves of pedicellariæ.

1. A valve 0.53 mm. Tridentate pedicellaria, exterior view, near the actinal system, from the right posterior ambulacrum of a specimen 18 mm. in diameter, including the spines.
2. A valve 0.55 mm. Tridentate pedicellaria, near the actinal system, from the left posterior ambulacrum, same specimen as 1.
3. A valve 0.71 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the right anterior ambulacrum of a specimen 35 mm. in diameter, including the spines.
4. A valve 0.66 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the odd anterior ambulacrum, same specimen as 3.
5. A valve 0.84 mm. Tridentate pedicellaria, at the ambitus, from the left anterior ambulacrum, same as 3.
6. A valve 0.83 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the odd posterior interambulacrum, same as 3.
7. A valve 0.81 mm. Tridentate pedicellaria, near the actinal system, from the right posterior ambulacrum of a specimen 67 mm. in diameter, including the spines.
8. A valve 0.85 mm. Tridentate pedicellaria, near the actinal system, from the left anterior ambulacrum, same specimen as 7.
9. A valve 0.90 mm. Tridentate pedicellaria, midway between the actinal system and the ambitus, from the left posterior ambulacrum, same as 7.
10. A valve 0.82 mm. Tridentate pedicellaria, at the ambitus, from the right posterior ambulacrum, same as 7.
11. A valve 0.47 mm. Tridentate pedicellaria, midway between the ambitus and the abactinal system, from the left anterior ambulacrum, same as 7.
12. A valve 0.74 mm. Tridentate pedicellaria, on the actinal side of the ambitus, from the right posterior ambulacrum, same as 7.
13. A valve 0.41 mm. Tridentate pedicellaria, near the ocular plate, from the left anterior ambulacrum, same as 7.
14. A valve 0.14 mm. Triphyllous pedicellaria, near the actinal system, from the left anterior ambulacrum, same as 7.
15. A valve 0.12 mm. Triphyllous pedicellaria, from the abactinal side of the ambitus, from the right posterior ambulacrum, same as 7.
16. A valve 0.11 mm. Triphyllous pedicellaria, near the apical system, from the left anterior ambulacrum, same as 7.

The same valve in each pedicellaria is figured. The enlargement of the figures is about the same. All the figures present an exterior view.

Hawaiian Ids., A. Garrett Coll.

PLATE 20.

Plate 20.

1-6. **Podophora atrata** Agass.

1. Seen from actinal side.
2. The same as 1 seen from actinal side denuded of its spines.
3. The same seen from the abactinal side.
4. Seen from the abactinal side, denuded of its spines.
5. Seen in profile facing the odd posterior interambulacrum.
6. The same denuded, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2, 3, and 4.

All figures are natural size.

Hawaiian Ids., A. Garrett Coll.

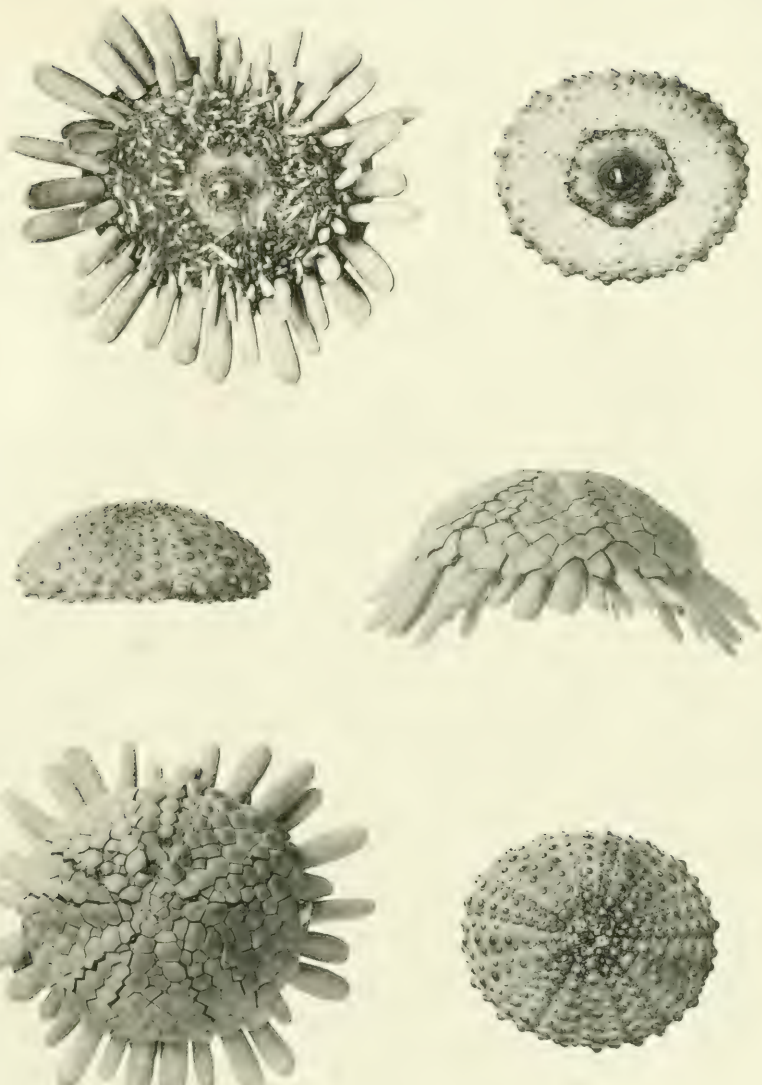


PLATE 21.

Plate 21.

1–6. **Podophora atrata** Agass.

1. Denuded test, seen from the actinal side.
2. The same seen from the abactinal side.
3. Seen in profile facing the odd anterior ambulacrum.
4. Seen from the actinal side.
5. The same seen from the abactinal side.
6. Profile of the same, facing the odd posterior interambulacrum.

All figures are natural size.

The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2, 4, 5.

Hawaiian Ids., A. Garrett coll.

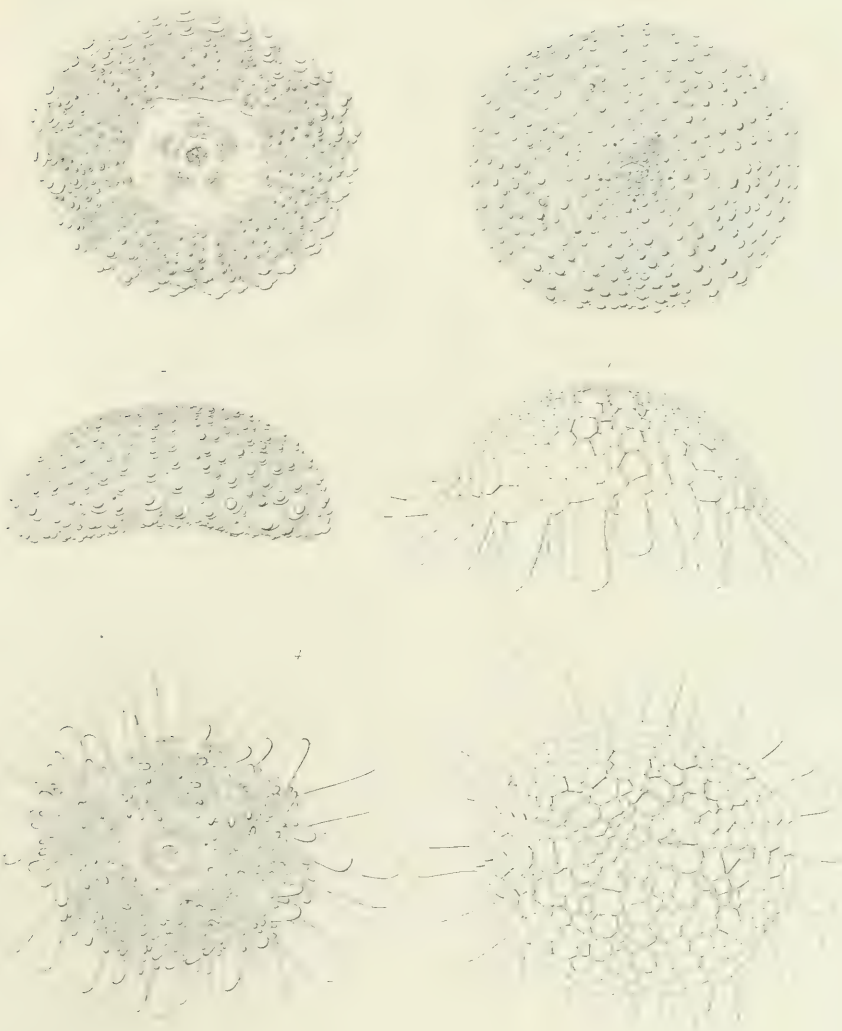


Plate 21a.

1–3. **Podophora atrata** Agass.

1. Specimen with club-shaped primary radioles, seen from the actinal side.
2. The same as fig. 1, seen from the abactinal side.
3. The same seen in profile facing the odd posterior interambulacrum.

The odd anterior ambulacrum is at the top of figures 1 and 2.

This specimen measures 92 mm., and was collected at Mauritius.

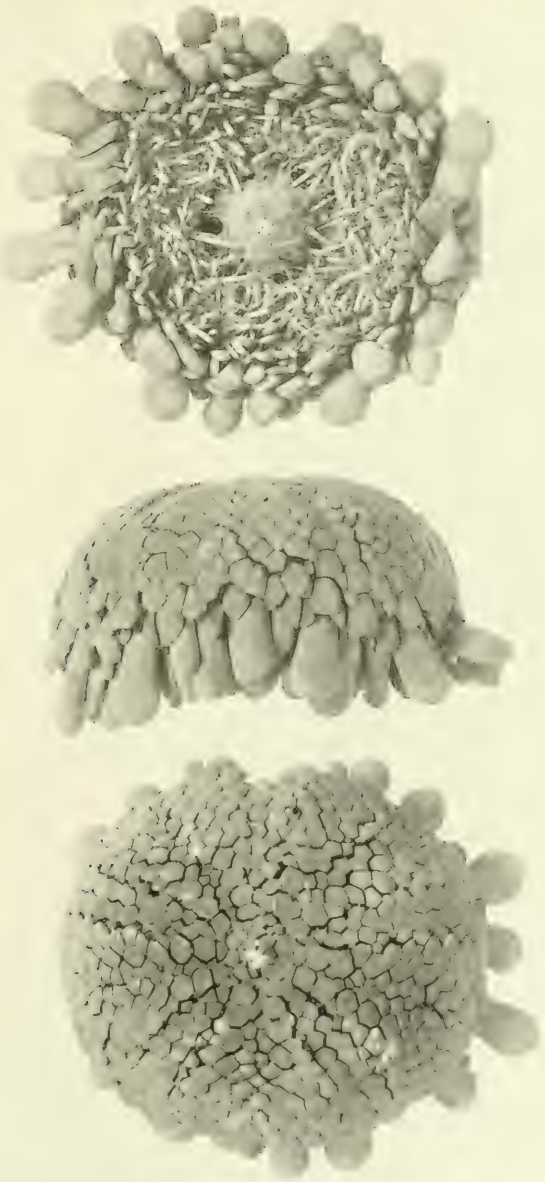


PLATE 21b.

Plate 21b.

1-3. **Podophora atrata** Agass.

1. Test seen from the actinal side.
2. The same seen from the abactinal side.
3. The same in profile facing the odd interambulacrum.

This specimen measures 97 mm. including the spines, collected at Mauritius by Nicolas Pike.

PLATE 22.

Plate 22.

1–10. **Podophora atrata** Agass.

1. From a specimen 12 mm. in diameter, including the spines.
2. From a specimen 14 mm. in diameter, including the spines.
3. From a specimen 18 mm. in diameter, including the spines.
4. From a specimen 26 mm. in diameter, including the spines.
5. From a specimen 31 mm. in diameter, including the spines.
6. From a specimen 35 mm. in diameter, including the spines.
7. From a specimen 46 mm. in diameter, including the spines.
8. From a specimen 67 mm. in diameter, including the spines.
9. From a specimen 74 mm. in diameter, including the spines.
10. From a specimen 77 mm. in diameter, including the spines.

The figures show the order of growth of the spines; the same view is given for each specimen, showing the left posterior ambulacrum, the odd posterior interambulacrum in the center, and one half of the right posterior ambulacrum.

The dotted lines join the radioles of the same vertical row.

Hawaiian Ids., A. Garrett Coll.

1
2
3
4
5
6
7
8
9
10

Plate 23.

1–33. Podophora atrata Agass.

1–33 Spines.

1. Spine, from the actinal system near the teeth.
2. Spine, near the actinal system, from the odd anterior ambulacrum.
3. Spine, lower surface, near the actinal system, from the left anterior interambulacrum.
4. Spine, upper surface, near the actinal system, from the left anterior interambulacrum.
5. Spine, profile, near the actinal system, from the left anterior interambulacrum.
6. Spine, upper surface, from the actinal side of the ambitus, from the left posterior interambulacrum.
7. Spine, lower surface, from the actinal side of the ambitus, from the left posterior interambulacrum.
8. Spine, profile, from the actinal side of the ambitus, from the left posterior interambulacrum.
9. Spine, upper surface, at the ambitus, from the right anterior ambulacrum.
10. Spine, lower surface, at the ambitus, from the right anterior ambulacrum.
11. Spine, profile, at the ambitus, from the right anterior ambulacrum.

These larger radioles vary in length from 15–20 mm.

12. Spine, upper surface, at the ambitus, from the left posterior interambulacrum.
13. Spine, lower surface, at the ambitus, from the left posterior interambulacrum.
14. Spine, profile, at the ambitus, from the left posterior interambulacrum.
15. Spine, lower surface, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
16. Spine, top view, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
17. Spine, profile, from the abactinal side, near the ambitus, from the right posterior ambulacrum.
18. Spine, upper surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
19. Spine, lower surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
20. Spine, profile, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
21. Spine, lower surface, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
22. Spine, top view, from the abactinal side, near the ambitus, from the right anterior interambulacrum.
23. Spine, profile, from the abactinal side, near the ambitus, from the right anterior interambulacrum.

24. Spine, side view, from the abactinal side, near the ambitus, from the right posterior interambulacrum.
25. Spine, profile, from the abactinal side, near the ambitus, from the right posterior interambulacrum.
26. Spine, lower side, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
27. Spine, profile, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
28. Spine, top view, midway between the ambitus and the abactinal side, from the right posterior interambulacrum.
29. Spine, lower surface, from the genital plates.
30. Spine, profile, from the genital plates.
31. Spine, top view, from the genital plates.
32. Spine, side view, from the madreporic plate.
33. Spine, from the abactinal side of the right posterior interambulacrum. These spines are hidden under the big primary radioles (see Pl. **11**, fig. *1*).

The enlargement of the figures is about the same. The shaded figs. *1*, *2*, and *33* are drawn on a larger scale.

Hawaiian Ids., A. Garrett Coll.

7
6
8

PLATE 24.

Plate 24.

1–8. **Podophora atrata** Agass.

1. Left anterior interambulacrum of a denuded specimen measuring 8 mm. in diameter.
2. The same interambulacrum from a denuded specimen 14 mm. in diameter.
3. The same interambulacrum from a denuded specimen 26 mm. in diameter.
4. The same interambulacrum from a denuded specimen 45 mm. in diameter.
5. A primary tubercle at the ambitus, on the fifth plate from the actinal system, the denuded test measuring 45 mm. in diameter.
6. The same, tubercle in profile.
7. The genital and last interambulacral plates, the seventh and eighth from the actinal system in the left anterior interambulacrum, of a denuded specimen, measuring 8 mm. in diameter.
8. The ninth and tenth plates of the left anterior interambulacrum, of a denuded test measuring 45 mm. in diameter.

Hawaiian Ids., A. Garrett Coll.

PLATE 25.

Plate 25.

1-10. Podophora atrata Agass.

1. Seen from abactinal side, with spines, measuring 14 mm. in diameter.
2. The same, denuded, seen from the actinal side, measuring 8 mm. in diameter.
3. The same seen from the abactinal side.
4. Profile of the same, facing the bivium and the odd posterior interambulacrum.
5. Interior view of the test of the same showing the abactinal system.
6. Left posterior ambulacral plates adjoining the actinal system.
7. Odd anterior ambulacrum at the ambitus.
8. Part of the abactinal system, the left anterior interambulacral and genital plates.
9. The odd anterior ambulacral plates adjoining the actinal system, of a denuded specimen measuring 45 mm. in diameter.
10. The same ambulacrum, partly on the actinal, and partly on the abactinal side of the ambitus.

Figures 1 to 8 are drawn from the same denuded specimen, measuring 8 mm. in diameter. Hawaiian Ids., A. Garrett Coll.

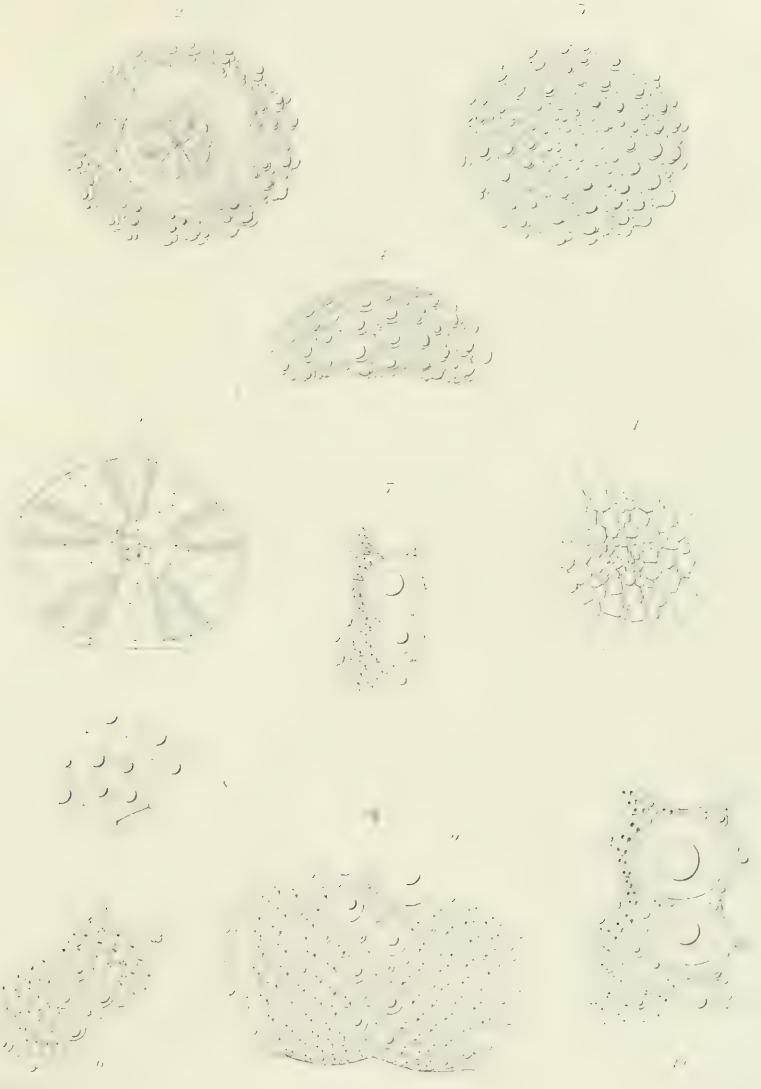


PLATE 26.

Plate 26.

1–16. Podophora atrata Agass.

1. Abactinal system, denuded of spines, of a specimen measuring 8 mm. in diameter.
2. The same, measuring with spines 14 mm. in diameter.
3. Abactinal system of a specimen measuring with spines 74 mm. in diameter, and denuded 45 mm.
4. Abactinal system, covered with spines, of a specimen measuring 77 mm. in diameter.
5. Anal system of a specimen 8 mm. in diameter.
6. Anal system of a specimen 14 mm. in diameter.
7. Anal system of a specimen 26 mm. in diameter.
8. Anal system of a specimen 45 mm. in diameter.
9. The auricles of the right anterior ambulacrum, seen from the interior of the test of a specimen 8 mm. in diameter.
10. The auricles of the left posterior ambulacrum, looking towards the actinostome, same specimen as 9.
11. Actinal part of the odd posterior interambulacrum, interior view of a specimen 8 mm. in diameter.
12. Auricles of the odd anterior ambulacrum, seen from the interior of the test of a specimen 14 mm. in diameter.
13. The same ambulacrum as 12 from a specimen 45 mm. in diameter.
14. Part of the odd anterior ambulacrum, seen from the interior.
15. Exterior view of the ocular and ambulacral plates of the left posterior ambulacrum of a specimen 8 mm. in diameter.
16. The same seen from the interior.

Figures 1, 5, 9–11, 15 and 16, are drawn from the same individual.

Hawaiian Ids., A. Garrett Coll.

PLATE 27.

Plate 27.

1-14. Podophora atrata Agass.

1. Lantern seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids, seen from the exterior.
4. The same as 3, seen from the interior.
5. The same seen in profile.
6. The same seen from above.
7. Pyramid, in profile, from the interior.
8. a. Epiphysis of pyramid, from the outside, b. top of a pyramid, in profile.
9. A tooth still in its socket.
10. a. Groove of tooth; b. dorsal view of tooth, c. seen in profile.
11. Part of 10 c. enlarged.
12. Upper part of tooth.
13. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
14. a. Compass seen from above, b. the same in profile.

All the figures are taken from a denuded specimen measuring 8 mm. in diameter. Hawaiian Ids., A. Garrett Coll.

2
6
1
7
3
4
5
8d
8a
b
11
a
b
c
12
11
a
b
10
a
b
c
11
9

PLATE 28.

Plate 28.

1-11. Podophora atrata Agass.

1. Lantern, seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids, seen from the exterior.
4. The same seen from the interior.
5. The same seen in profile.
6. Same seen from above.
7. a. Epiphysis of pyramid seen from the inside, b. pyramid seen in profile from the interior.
8. a. Epiphysis of pyramid from the exterior, b. upper end of a pyramid seen from the exterior.
9. a. Groove of tooth, b. dorsal view of tooth, c. seen in profile.
10. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
11. a. Compass seen from above, b. the same in profile.

The figures are drawn from a denuded specimen 45 mm. in diameter.
Hawaiian Ids., A. Garrett Coll.

1
2
3
4
5
6
7a
8a
b
9
10
11
a
b
c
d

Plate 29.

1–17. Colobocentrotus Stimpsoni A. Ag.

1–17. Valves of pedicellariæ.

1. A valve 0.41 mm. of an Ophicephalous pedicellaria, exterior view, near the teeth.
2. A valve 0.36 mm. Ophicephalous pedicellaria, interior view, near the teeth.
3. A valve 0.48 mm. Ophicephalous pedicellaria, exterior view, nearer the actinal system than the ambitus, from the odd anterior ambulacrum.
4. A valve 0.50 mm. Ophicephalous pedicellaria profile, interior view, nearer the actinal system than the ambitus, from the right anterior ambulacrum.
5. A valve 0.51 mm. Ophicephalous pedicellaria, interior view.
6. A valve 0.51 mm. Ophicephalous pedicellaria, midway between the actinal system and the ambitus, from the left anterior ambulacrum.
7. A valve 0.88 mm. Tridentate pedicellaria, exterior view, not far from the actinal system, from the left posterior ambulacrum.
8. A valve 0.78 mm. Tridentate pedicellaria, interior view.
9. A valve 0.86 mm. Tridentate pedicellaria, profile, exterior view.
10. A valve 0.47 mm. Ophicephalous pedicellaria, showing the articulation near the ambitus, from the left anterior interambulacrum.
11. A valve 0.47 mm. Ophicephalous pedicellaria, interior view, nearer the ambitus than the actinal system, from the right anterior interambulacrum.
12. A valve 0.47 mm. Ophicephalous pedicellaria, interior view near the ambitus, from the right anterior interambulacrum.
13. A valve 0.36 mm. Ophicephalous pedicellaria, exterior view midway between the ambitus and the abactinal system, from the right anterior interambulacrum.
14. A valve 0.17 mm. Triphyllous pedicellaria, midway between the actinal system and the ambitus, from the left anterior interambulacrum.
15. A valve 0.16 mm. Triphyllous pedicellaria, from the same, interior view of a single valve.
16. A valve 0.34 mm. Ophicephalous pedicellaria, interior view not far from the ocular plate, from the left posterior ambulacrum.
17. A valve 0.9 mm. Triphyllous pedicellaria, exterior view close to the ocular plate, of the right posterior ambulacrum.

The enlargement of the pedicellariæ of the actinal system is somewhat greater than that of figs. 7–9 which are drawn on a smaller scale.

All the figures are from a specimen 88 mm. in diameter including the spines. Collected by Dr. Wm. Stimpson at the Bonin Ids.

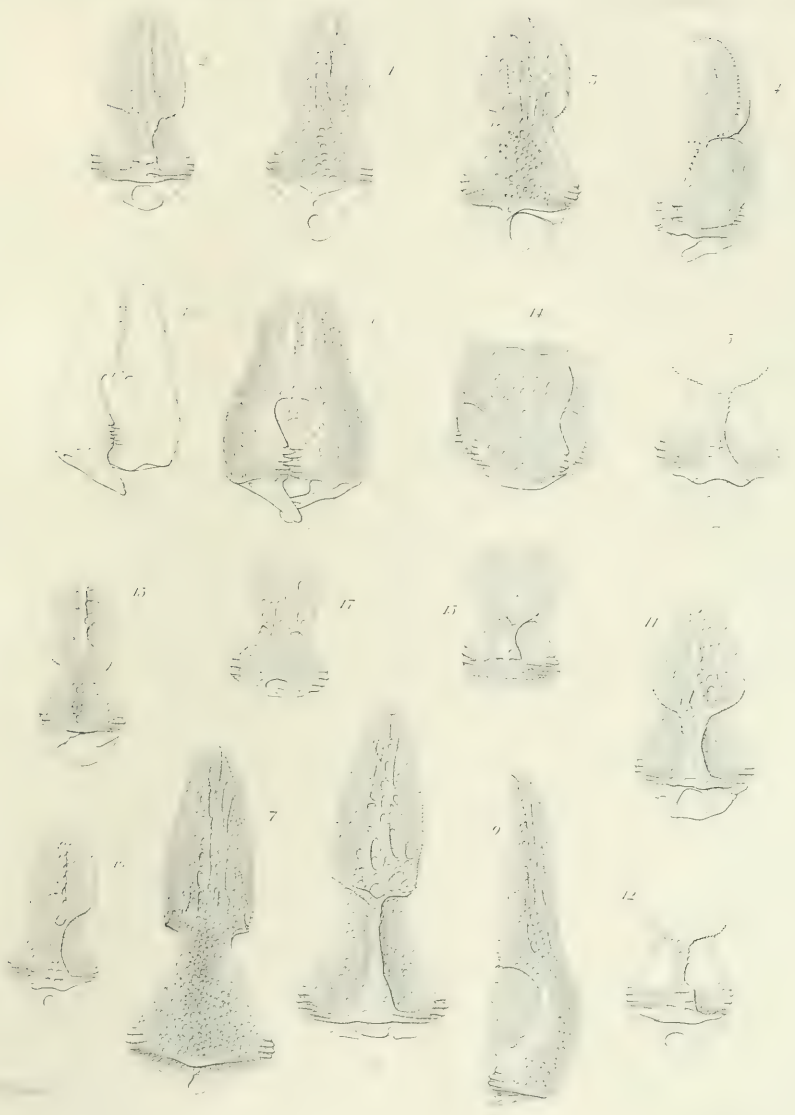


PLATE 30.

Plate 30.

1-16. Colobocentrotus Mertensii Brandt.

1–16. Valves of pedicellariæ.

1. A valve 0.38 mm. } Ophicephalous pedicellaria, interior view near the teeth.
2. A valve 0.35 mm. } Ophicephalous pedicellaria, exterior view, near the teeth.
3. A valve 0.81 mm. } Tridentate pedicellaria, exterior view, close to the actinal system from the odd anterior ambulacrum.
4. A valve 0.78 mm. } Tridentate pedicellaria, interior view of the same pedicellaria as 3.
5. A valve 0.77 mm. } Tridentate pedicellaria, profile, interior view of the same as 3.
6. A valve 0.54 mm. } Tridentate pedicellaria, exterior view, midway between the ambitus and the actinal system, from the left posterior ambulacrum.
7. A valve 0.41 mm. } Tridentate pedicellaria, interior view, from the left posterior ambulacrum.
8. A valve 0.47 mm. Tridentate pedicellaria, close to the ambitus, from the right anterior ambulacrum.
9. A valve 0.48 mm. Ophicephalous pedicellaria, exterior view, close to the ambitus, from the right anterior ambulacrum.
10. A valve 0.12 mm. } Triphyllous pedicellaria, exterior view, midway between the actinal system and the ambitus, from the left anterior ambulacrum.
11. A valve 0.14 mm. } Triphyllous pedicellaria, profile, same pedicellaria as 10.
12. A valve 0.46 mm. } Ophicephalous pedicellaria, interior view close to the ambitus, from the right anterior interambulacrum.
13. A valve 0.44 mm. } Ophicephalous pedicellaria, exterior view of same pedicellaria as 12.
14. A valve 0.31 mm. } Ophicephalous pedicellaria, interior view midway between the ambitus and the abactinal system, from the left posterior interambulacrum.
15. A valve 0.27 mm. } Ophicephalous pedicellaria, exterior view of the same pedicellaria as 14.
16. A valve 0.9 mm. Triphyllous pedicellaria, exterior view, close to the ocular plate, from the right anterior ambulacrum.

From a specimen measuring 70 mm. in diameter, with spines.

Bonin Ids., N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

PLATE 31.

Plate 31.

1–4. **Podophora pedifera** Agass.

1–8. Sphæridia.

1. Sphæridia, the first measures 0.27 mm. in length, all from the right posterior ambulacrum.
2. From the odd anterior ambulacrum, the longest measures 0.34 mm., the length of its mate is 0.29 mm.
3. The first figure measures 0.28 mm., the second 0.19 mm., from the left anterior ambulacrum.
4. From the left posterior ambulacrum, the first figure measures 0.26 mm.

5–8. **Podophora atrata** Agass.

5. Three sphæridia from the right posterior ambulacrum, the middle one measures 0.26 mm.
6. From the odd anterior ambulacrum, the second figure measures 0.25 mm.
7. Sphæridia from the left anterior ambulacrum, the third figure measures 0.26 mm.
8. From the left posterior ambulacrum, the second figure measures 0.29 mm.

The sphæridia of 1–4 are from the same specimen, measuring 85 mm. in diameter, including the spines, and those of 5–8 are from an individual measuring 77 mm.

The enlargement of the figures is about the same.

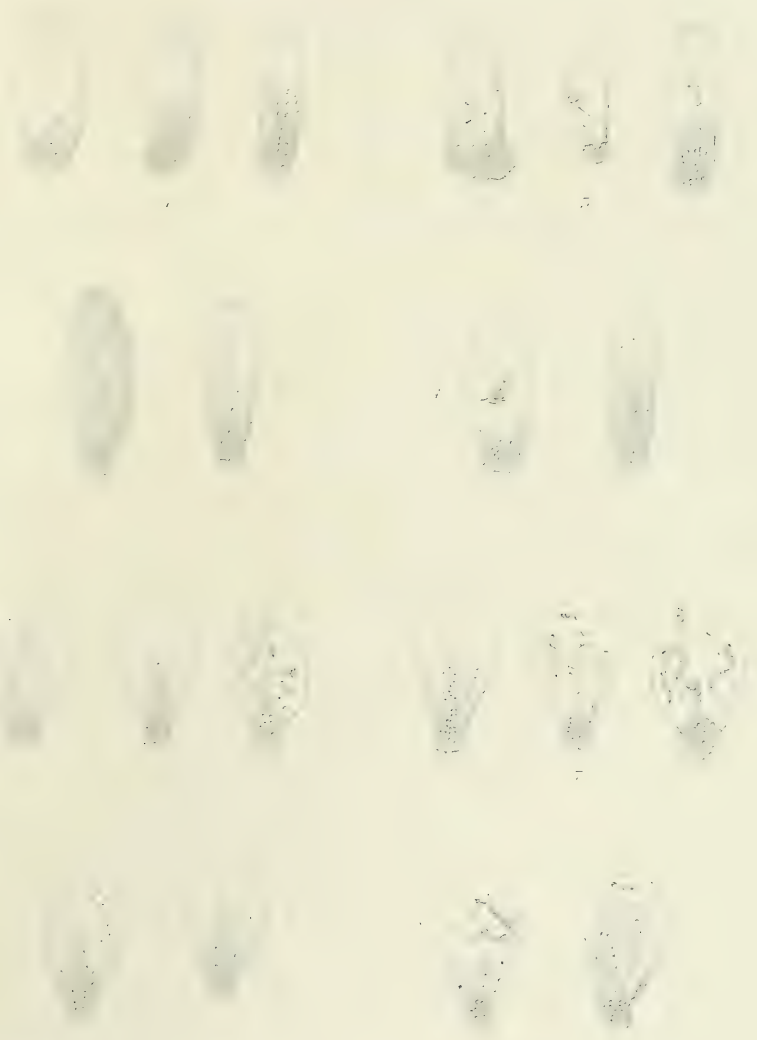


PLATE 32.

Plate 32.

1–4. **Colobocentrotus Stimpsoni** A. Ag.

1–8. Sphæridia.

1. Sphæridia, the second measures 0.25 mm. in length; all the sphæridia are from the right posterior ambulacrum.
2. From the odd anterior ambulacrum, the first measures 0.26 mm. in length.
3. The second figure measures 0.27 mm. in length; from the left anterior ambulacrum.
4. From the left posterior ambulacrum, the first figure measures 0.22 mm. in length, the second 0.27 mm.

5–8. **Colobocentrotus Mertensii** Brandt.

5. Three sphæridia from the right posterior ambulacrum, the last one measuring 0.26 mm. in length.
6. From the odd anterior ambulacrum, the first figure measures 0.27 mm. in length and the fourth one 0.23 mm.
7. Sphæridia from the left anterior ambulacrum, the second figure measures 0.25 mm. in length.
8. From the left posterior ambulacrum, the first figure measures 0.28 mm. in length.

The sphæridia of 1–4 are from the same specimen, 88 mm. in diameter, including the spines and those of 5–8 from an individual measuring 70 mm.

The enlargement of the figures is about the same.

Bonin Ids., N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

PLATE 33.

Plate 33.

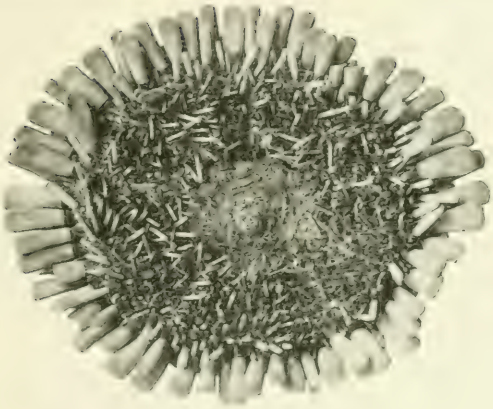
1–3. Colobocentrotus Stimpsoni A. Ag.

1. Seen from the actinal side.
2. Seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

The odd anterior ambulacrum occupies the center of the upper part of figures 1, 2.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



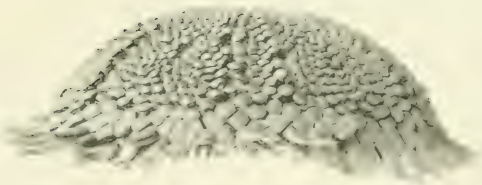


PLATE 34.

Plate 34.

1–3. Colobocentrotus Stimpsoni A. Ag.

1. Seen from the actinal side; denuded of its spines.
2. The same seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

Plate 35.

1–3. **Colobocentrotus Mertensii** Brandt.

1. Seen from the actinal side.
2. Seen from the abactinal side.
3. The same specimen, seen in profile, facing the odd anterior ambulacrum.

All figures are natural size.

The odd anterior ambulacrum occupies the center of the upper part of figs. 1, 2.

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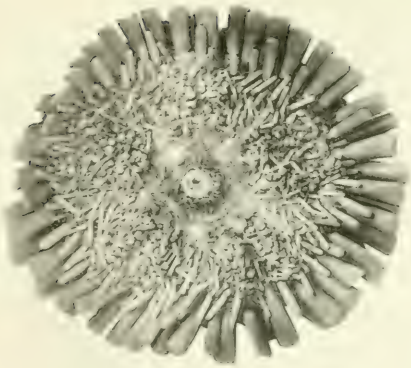
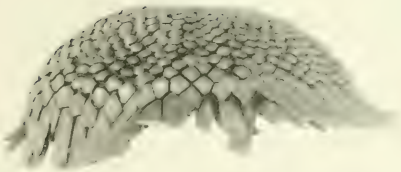




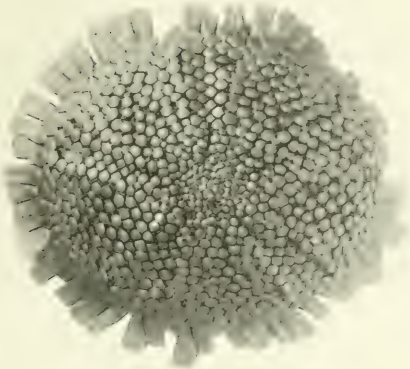


PLATE 36.

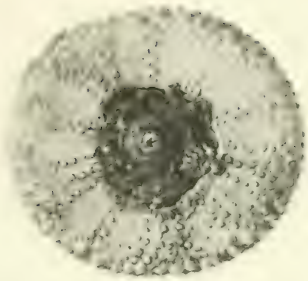
Plate 36.

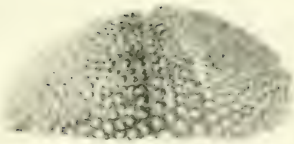
1–3. **Colobocentrotus Mertensii** Brandt.

1. Seen from the actinal side.
2. The same seen from the abactinal side.
3. The same specimen, seen in profile, facing the bivium and odd posterior interambulacrum.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.





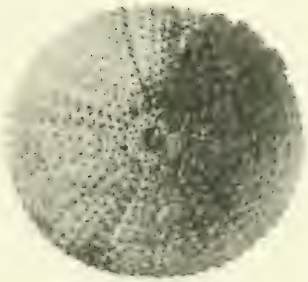


PLATE 37.

Plate 37.

1-3. Colobocentrotus Stimpsoni A. Ag.

1. Seen from the actinal side, measuring 88 mm. in diameter including the spines.
2. The same seen from the abactinal side.
3. Profile of the same facing the odd anterior ambulacrum.

All figures are natural size.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

PLATE 38.

Plate 38.

1-3. **Colobocentrotus Stimpsoni** A. Ag.

1. The same as the specimen figured on Plate 37, seen from the actinal side, denuded of its spines, measuring 65 mm. in diameter.
2. The same seen from the abactinal side.
3. Profile of the same, facing the odd anterior ambulacrum.

All figures are natural size.

Bonin Isls., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

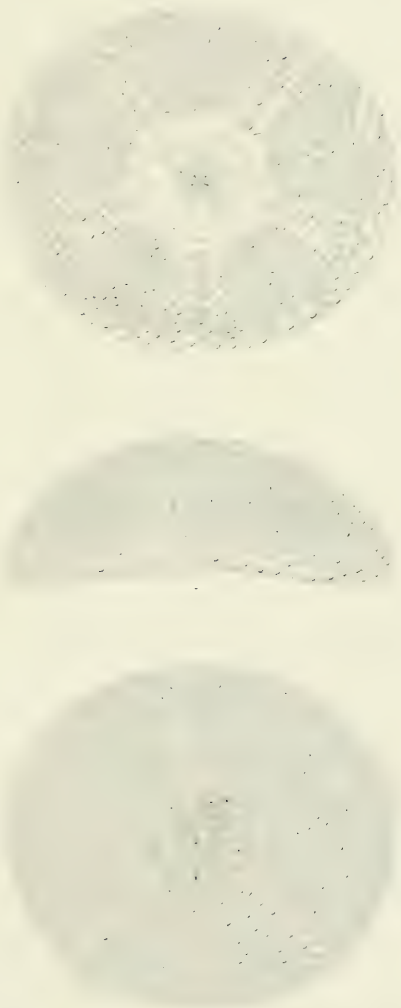


PLATE 39.

Plate 39.

1–2. **Colobocentrotus Mertensii** Brandt.

1. Showing the right posterior ambulacrum, with the right posterior interambulacrum, and a part of the right anterior ambulacrum.
2. Showing the odd posterior interambulacrum with the bivium, and half of the right posterior ambulacrum.

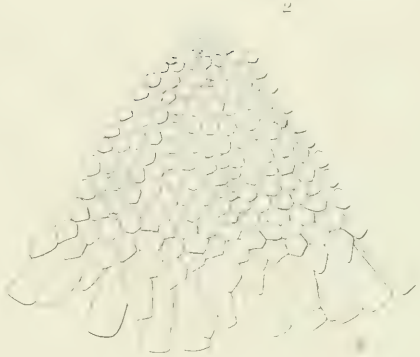
3–4. **Colobocentrotus Stimpsoni** A. Ag.

3. The right posterior interambulacrum, with the right posterior ambulacrum and a part of the right anterior ambulacrum.
4. The right anterior interambulacrum, with the right anterior ambulacrum and a part of the odd anterior ambulacrum.

1–2 are from a specimen of 70 mm. in diameter, and 3–4 from a specimen measuring 88 mm. in diameter, including the spines. The dotted lines join the radioles of the same vertical row.

Bonin Ids., N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

1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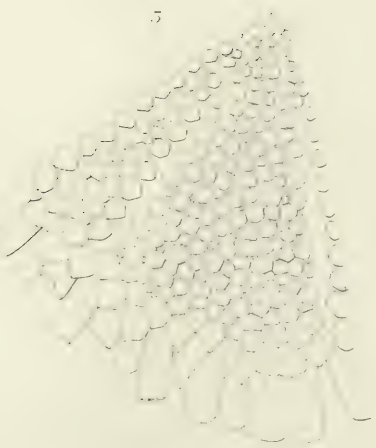

3

4

PLATE 40.

1-32. Colobocentrotus Stimpsoni A. Ag.

1–32. Spines.

1. Spine, from the buccal membrane close to the teeth.
2. Spine, from the actinal system.
3. Spine, lower side, midway between the actinal system and the ambitus.
4. Spine, profile of same as 3.
5. Spine, lower side, from the actinal side of the ambitus, from the left anterior ambulacrum.
6. Spine, upper side.
7. Spine, lower side, from the actinal side near the ambitus, from the left anterior ambulacrum.
8. Spine, profile.
9. Spine, upper side.
10. Spine, lower side, at the ambitus, from the right posterior ambulacrum. These larger radioles vary in length from 12 to 15 mm.
11. Spine, profile.
12. Spine, upper side.
13. Spine, lower side, from the abactinal side, near the ambitus, from the left anterior ambulacrum.
14. Spine, profile.
15. Spine, upper side.
16. Spine, lower side, from the abactinal side near the ambitus, from the left posterior interambulacrum.
17. Spine, profile.
18. Spine, top view.
19. Spine, lower side, midway between the ambitus and the abactinal system, from the odd anterior ambulacrum.
20. Spine, profile.
21. Spine, top view.
22. Spine, lower side, from the abactinal side towards the ambitus, from the left posterior ambulacrum.
23. Spine, profile.
24. Spine, upper side, from the upper extremity of the left anterior ambulacrum.
25. Spine, lower side from the upper extremity of the left anterior ambulacrum.
26. Spine, top view, from the upper extremity of the right posterior interambulacrum.
27. Spine, lower side from the upper extremity of the right posterior interambulacrum.
28. Miliary spine, near the upper extremity of the right posterior interambulacrum, — hidden by the primary radioles.
29. Miliary spine, lower side, from the anal system.
30. Miliary spine, lower side, from the anal system.
31. Miliary spine, upper side, from the anal system.
32. Miliary spine, profile, from the anal system.

The figures are from the same specimen, measuring 88 mm. in diameter.

All the figures are about equally enlarged, except the shaded figures 1, 2, 5, 28, which are considerably enlarged, as is shown by the adjoining outlines.

Bonin Ids., Dr. Wm. Stimpson Coll.

PLATE 41.

Plate 41.

1–7. **Colobocentrotus Stimpsoni** A. Ag.

1. The left anterior interambulacrum.
2. The ninth and tenth plates from the actinal system of the left anterior interambulacrum.
3. Showing the large tubercle of the fifth plate from the actinal system at the ambitus of the left posterior interambulacrum.
4. The same, seen in profile.
5. One of the primary interambulacral tubercles on the abactinal side.
6. Grouping of the miliaries on the actinal side of the right posterior interambulacrum.
7. Genital plate and pore of the left anterior interambulacrum.

All the figures are from the same specimen, measuring 88 mm. in diameter, including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

PLATE 42.

Plate 42.

1–8. **Colobocentrotus Stimpsoni A. Ag.**

1. Interior view of the actinal side.
2. One of the pairs of perforated plates of the buccal membrane, facing the odd anterior ambulacrum.
3. Exterior view of the odd anterior ambulacral plates adjoining the actinal system.
4. The same seen from the interior of the test.
5. The tenth plate from the actinal system of the odd anterior ambulacrum.
6. The same seen from the interior.
7. Interior view of a plate of the right posterior ambulacrum at the ambitus.
8. The ocular plate and the abactinal extremity of the left posterior ambulacrum, seen from the interior.

In figures 3, 4, and 5, 6, a small cross shows the slanting perforation of the pore through the test.

From a specimen measuring 88 mm. in diameter including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

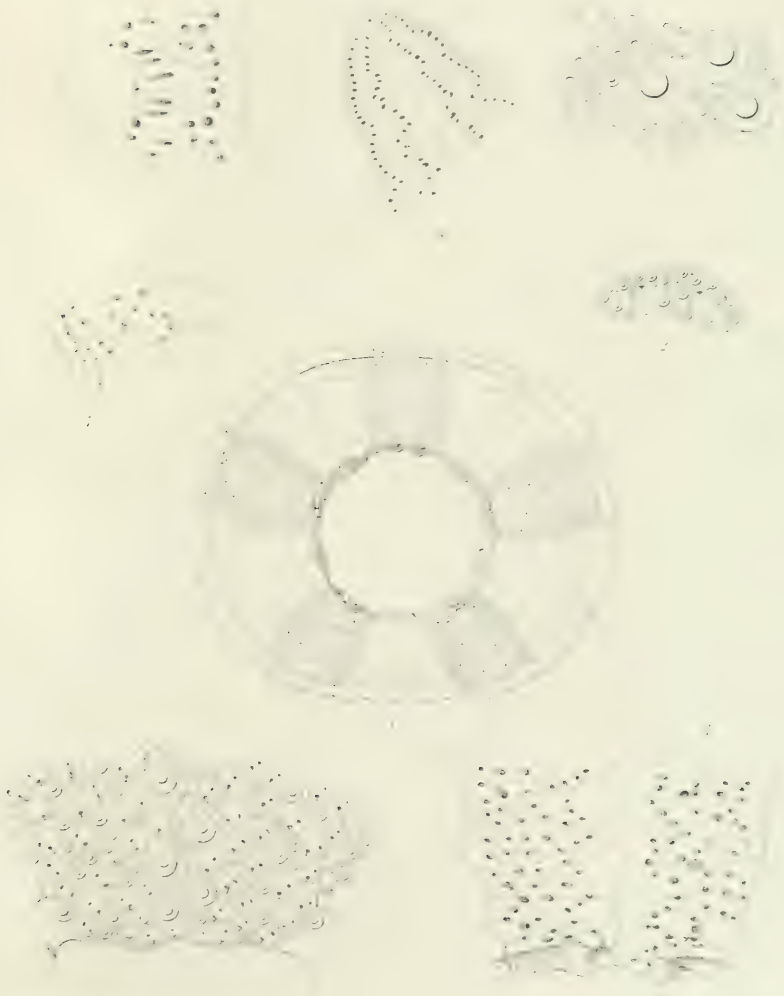


PLATE 43.

Plate 43.

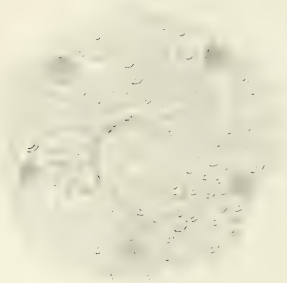
1–7. **Colobocentrotus Stimpsoni A. Ag.**

1. The abactinal system, before being denuded of its spines.
2. The abactinal system of the same, denuded.
3. The same, seen from the interior of the test.
4. The auricles of the right posterior ambulacrum, seen from the interior of the test.
5. The auricles as seen looking towards the actinostome through the auricular opening of the left posterior ambulacrum.
6. Plates of the right anterior interambulacrum adjoining the actinal system, seen from the interior of the test.
7. Plates of the odd posterior interambulacrum bordering on the actinal system.

Figs. 6, 7, seem to show the remnant of the ambulacral primordial plates.

From a specimen measuring 88 mm. in diameter including the spines.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.



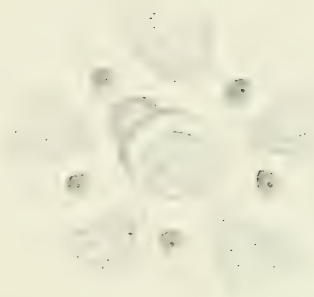


PLATE 44.

Plate 44.

1-12. **Colobocentrotus Stimpsoni** A. Ag.

1. Lantern seen from above.
2. The same as 1, seen in profile.
3. One of the pyramids, seen from the exterior.
4. The same as 3, seen from the interior.
5. The same, seen in profile.
6. The same, seen from above.
7. a. Epiphysis of pyramid, from the interior, b. pyramid, in profile, from the interior.
8. a. Epiphysis of pyramid, from the exterior, b. pyramid, in profile, from the exterior.
9. Edge of the corrugated surface of pyramid somewhat more enlarged.
10. a. Groove of tooth, b. tooth seen in profile.
11. a. The brace, seen from above, b. seen in profile, c. from below, d. endwise.
12. a. Compass seen in profile, b. seen from above.

All the figures from a denuded specimen 65 mm. in diameter.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

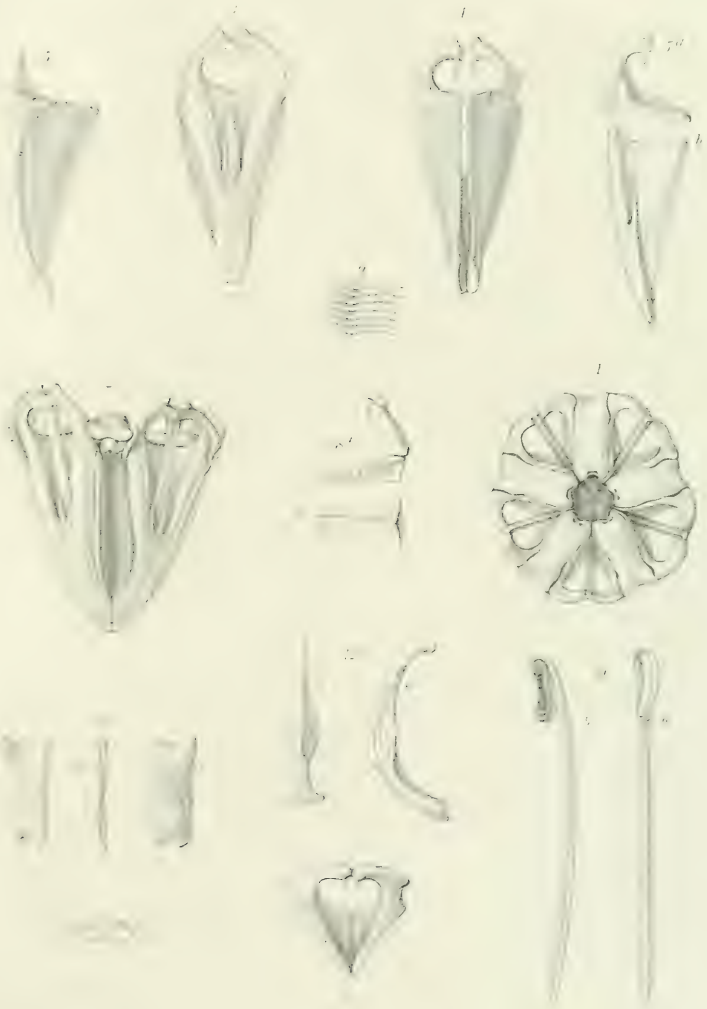


PLATE 45.

Plate 45.

1–5. **Colobocentrotus Stimpsoni A. Ag.**

1. The disk of an actinal pedicel.
2. The basal part of one of its laminæ.
3. Part of a typical spicule.
4. A deformed spicule.
5. Fragment of a deformed spicule.

6–10. **Colobocentrotus Mertensii Brandt.**

6. Fragment of a spicule.
7. Basal part of a lamina.
8. Shows the quadratic arrangement of the spicules.
9. Typically formed spicule.
10. Top of a pedicel, taken from the abactinal side and hidden by the large radioles.

Figures 1–5 are from a specimen, 88 mm. in diameter including the spines and those of 6–10 from an individual, measuring 70 mm. in diameter.

Bonin Ids., Captains Ringgold and Rodgers, N. P. Ex. Ex., Dr. Wm. Stimpson Coll.

PLATE 46.

Plate 46.

1–4. **Podophora pedifera Agass.**

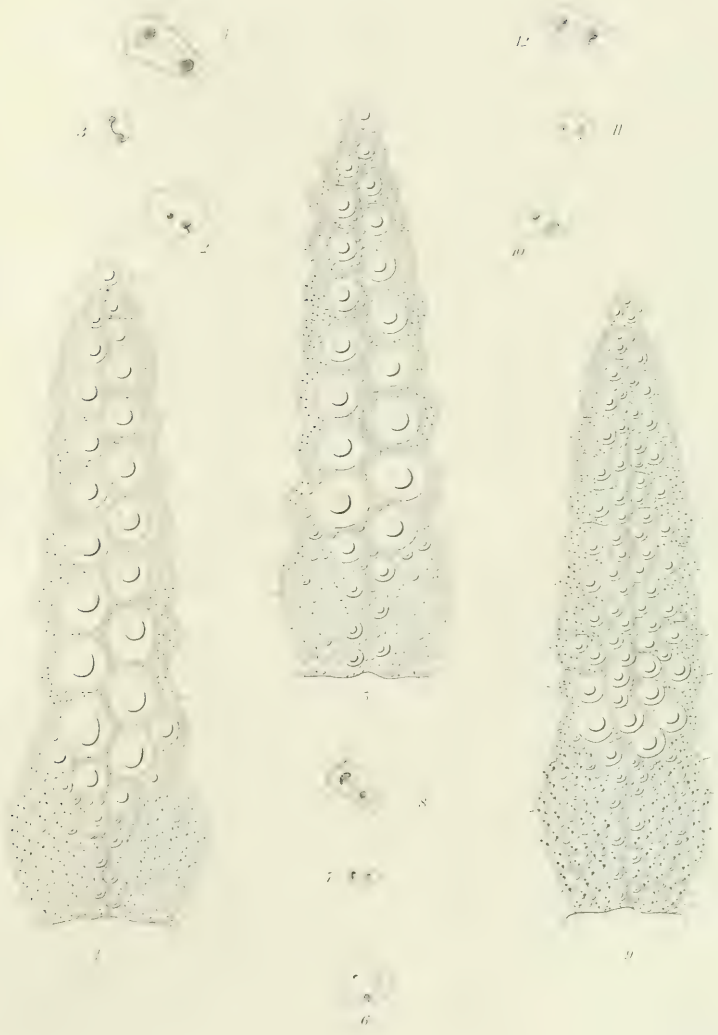
1. The odd anterior ambulacrum of a denuded specimen 55 mm. in diameter.
2. Pore near the actinal system, from the same specimen.
3. Pore at the ambitus.
4. One of the pores of the ninth plate from the actinal system.

5–8. **Podophora atrata Agass.**

5. The odd anterior ambulacrum of a denuded specimen 46 mm. in diameter.
6. Pore near the actinal system, corresponding to the pore of fig. 5.
7. Pore at the ambitus.
8. One of the pores of the eighth plate from the actinal system.

9–12. **Colobocentrotus Stimpsoni A. Ag.**

9. The odd anterior ambulacrum, of a denuded specimen 65 mm. in diameter.
10. Pore near the actinal system corresponding to the pore of fig. 5.
11. Pore at the ambitus.
12. One of the pores of the eleventh plate from the actinal system.



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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, to MARCH, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

XV.

ECHINI.

ECHINONËUS AND MICROPETALON.

By A. M. Westergren.

WITH THIRTY-ONE PLATES.

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TROPICAL PACIFIC ECHINI.

ECHINONËUS AND MICROPETALON.

INTRODUCTORY NOTE.

At the time of his death Mr. Agassiz had in view the publication of a Report on the genus Echinonëus, the illustrations for which I had worked upon, first in 1903 and later in 1908, until their completion in August, 1910.

The material in the collections in the Museum of Comparative Zoölogy at my disposal for study and for the preparation of the illustrations was excellent there being no less than two hundred and forty-four specimens of which one hundred and sixty were alcoholic, and the remainder dry bare tests. They range in size from a length of about three millimetres up to nearly forty. They come from different localities in the West Indies, the Pacific and East Indian regions.

Besides the above Dr. Richard Rathbun of the U. S. National Museum had the kindness to send for comparison two perfect adult specimens in alcohol, collected during U. S. Eclipse Expedition of 1889 to West Africa, which though labeled Ascension Is.,? were probably obtained at Barbados.

As a result of the examination of this material, Mr. Agassiz had reached the conclusion that it represents a single species, for which *cyclostomus* Leske (1778), seems to be the earliest available name. Linne's name *ovalis* (1753) would have been preferable but unfortunately was used prior to 1758.

From Mr. Agassiz's paper "On the existence of teeth and of a lantern in the genus Echinonëus Van Phels" (Amer. Journ. Sci., November, 1909, ser. 4, **28**, p. 490–492, pl. 2) I quote:—

"This is perhaps one of the most interesting recent discoveries in the domain of echinology, considering the relationship hitherto recognized of Echinonëus to the Atelostomata. The presence of teeth would transfer them to the vicinity of such types of the exocycla Gnathostomata as Holectypus, Discoidea, Pygaster (Echinoconidæ) and more remotely to the Conoclypidæ. * * *

"Young specimens of Echinonëus * * * and but slightly larger than those

in which teeth were observed, have no teeth or lantern * * * and nothing is left of them * * * so that in the older and adult stages of Echinonëus its relationship to the Spatangoids is in no way modified. * * *

"It is interesting to note that this dentate stage of Echinonëus should connect the embryonic Spatangoids with the early stages of Clypeastroids and of the Echinoconidæ, while the toothed Pygastroides of Lovén connects it with some of the Echinoconidæ; both Echinonëus and Pygastroides are West Indian genera.

"The presence or absence of auricles, teeth and pyramids forms the basis of Zittel's classification of the irregular Echini into Gnathostomata and Atelostomata. The position of the anal system on the actinal surface close to the actinostome is a very modern feature: its gradual passage from an anal system enclosed within the calycinal system as in Pygaster, where it is outside of the abactinal system, can be traced towards the ambitus to the ambitus and finally to an actinal position.

"In some of the Holectypidæ the jaws are greatly reduced in size and solidity and their importance much lessened, and in others the jaws have entirely disappeared, the perignathic girdle having become rudimentary. In the Echinometradæ the auricular girdle is most highly developed. In the Holectypidæ we find primitive irregular Echini as well as types which have persisted to the present day. In the Discoidea and Galerites the ambulacral processes and teeth are absent; in the auricular girdle the processes become low. In the Clypeastroids there are neither braces nor compass, the jaws move horizontally, and finally in the Atelostomata the girdle and jaws are completely absent. We may imagine the process of resorption of the lantern of Echinonëus to have gone through some such succession."

The specimens upon which Mr. Agassiz based the above remarks were collected by Dr. H. L. Clark who has kindly supplied the following notes:—

"Echinonëus occurs at Port Antonio, Jamaica, only in the sand-flat within the reef on the north and west sides of Litchfield Point. Search in similar habitats in the vicinity of Port Antonio, both in 1897 and in 1909, failed to reveal a single specimen.

"On this sand-flat, which is more or less covered by a feeble growth of short eel-grass, are numerous fragments of coral-rock, ranging from a few inches to two or three feet in diameter. These fragments are more or less imbedded in the sand and it is under them that Echinonëus occurs, commonly in company with *Brissus unicolor* Klein. As a rule, both these species are completely buried

in the sand and are found only by sifting the sand. A flour scoop proved the best implement for digging up the sand, and then passing it through a set of sieves, the lowest having a very fine mesh. By the use of such sieves some small specimens were obtained which it would have been practically impossible to have obtained in any other way. In rare instances, specimens were found clinging to the rock overturned, but as they were clinging by the abactinal tube-feet, it is evident they were only accidentally pulled up with the rock. Careful examination of the sand *around* the rock-fragments (not beneath them) and in areas not under rocks always failed to reveal Echinonëus or Brissus. It seems as though rock-fragment were the essential factor in determining the exact habitat. This may however be true in very shallow water only, for the Litchfield sand-flat is covered at high tide by only 1–3 feet of water and at low tide much of it is bare.

"As in many regular Echini, the tube-feet of Echinonëus are used to hold sand-grains and particles of dirt close against the test, thus more or less concealing the animal.

"For this reason specimens only a few millimeters long are very hard to see, the large flat grains of sand (derived apparently from calcareous Algae) affording an admirable means of concealment. When placed in a glass dish of sea-water, without any sand, Echinonëus stretches the abactinal tube-feet out far beyond the spines as though hunting for something, but after a short time, they are retracted below the spines. If sand is present the animal soon covers itself. In or on a sufficient amount of sand, the movement of the animal is very evident. Both spines and tube-feet appear to be used in locomotion.

"The color of Echinonëus is whitish with a more or less marked reddish tint. One small specimen was found the whole abactinal surface of which was deep red. The tube-feet are clear, translucent red (more rose than scarlet, yet not a rose-red), in marked contrast to the test and spines, so that the ambulacra stand out sharply. The color seems to be very easily affected by reagents, becoming much darker than normal in alcohol, or glycerine. Formalin turns the red shades to yellowish green ultimately becoming greenish yellow. A strong salt solution (NaCl in fresh-water) kept the colors fairly well for a short time (24–48 hours) but specimens so treated afterwards became dingy brownish. Mixtures of alcohol and formalin and of alcohol, formalin and glycerine were of no avail, whether made up with fresh- or sea-water. The specimens which are now nearest natural color are certain young ones treated only with pure alcohol or pure glycerine.

"In size, Echinonëus rarely exceeds an inch in length. The specimens taken range from 4 to 27 mm. Most of them are between 8 and 18. The form of the test is very variable, the proportions of width to length, height to width, etc. showing much diversity. (In 1897, a bare test was found 42 mm. long.)

"It is quite possible that large specimens occur in deeper water, outside the reef, but this is simply a conjecture.

"The absence of specimens less than 4 mm. long is greatly to be regretted, but it seems almost certain that such young ones must occupy a different habitat from the adults. Since it is probable that there is a free swimming larval stage, it is quite possible that the absence of specimens under 3 mm. in length from the sand where the adults occur may be explained as follows:—after the metamorphosis, or at least at the conclusion of the free-swimming stage, the young Echinonëus settles on the calcareous Algae, eel-grass, or other vegetation surrounding undisturbed fragments of coral rock on the sand-flat, and only slowly moves downward to and into the sand beneath the rock. By the time the sand is reached, the Echinonëus is 2 or 3 mm. in length."

Echinonëus cyclostomus Leske.

The Outline of the Ambitus.

Plates 4, 5.

With material limited to a few specimens the specific characters seem easily distinguished, but with an abundance of specimens the supposed differences are at least doubtful. Pls. 4 and 5, give a far better idea of the characteristics of the test than any description.

The figure of a fossil *E. michaleti* given by Cotteau and of de Loriol's *E. abnormalis* from Mauritius, are exactly identical in outline with the one shown (Pl. 5, fig. *4*) from Mauritius, and also with that collected in 1868 by Count Pourtalès at Caryfort Reef, Florida (Pl. 5, fig. *17*) all of which have an almost circular ambitus; the anal system in the smallest Florida specimen being much longer than in the other.

In comparing two specimens of nearly equal length from the same locality, Lord Lowe Island, N. S. Wales (Pl. 5, figs. *1*, *2*), it will be seen that the ambitus of the smallest, fig. 1, is between an ovoid and a pentagon in shape, and that the anal system is elongated, while in the other, fig. *2*, the ambitus is unevenly pointed at the anterior end with a longer distance between the anterior ambulacrum on the left side and the anal system is short.

The ambitus in a specimen from Mauritius, Pl. 5, fig. *4*, is circular, while in two adult specimens, also collected at Mauritius in 1873, only one of which is figured, Pl. 5, fig. *3*, it is more ovoid in shape with a broad blunt posterior end; and the well-defined tubercles, the raised and rounded ambulacra, show little similarity to any of the other figures on Pls. 4 and 5.

Diversity in the shape of the ambitus is also shown on Pl. 4, figs. *7*, *20*, and Pl. 5, figs. *7–10*; all the specimens figured are from the Pacific and by the same collector. On Pl. 4, fig. *7*, the ambitus is an ellipsoid and the mouth and anus are small; the outline of the test is compressed to an ellipsoid with a posterior pointed end, and the anal system is elongated, nearly reaching the ambitus, (Pl. 4, fig. *20*). The same irregularity of the ambitus is shown (Pl. 5, figs. *7–10*), and the actinostome and anal system varies in form and size out of proportion to the length of the tests. These specimens were water-worn, the tubercles being partly destroyed.

A specimen from Makemo Island, Paumotu Islands, Exped. "Albatross" 1899–1900, presents an actinostome and anal system toward the right side of the test; in other specimens the odd anterior ambulacrum also frequently inclines toward either the right or the left side.

The larger of two specimens from Bourbon (Pl. 4, figs. *3*, *11*), recalls the specimen from Lord Howe Island (Pl. 5, fig. *2*), and the smaller one is identical with that from Makemo Island. Three tests from the Gilbert Islands (Pl. 4, figs. *12*, *15*, *18*), of nearly the same size, are unlike in shape but are in every way similar to the young specimen from Mujeres Island, Yucatan (Pl. 4, fig. *19*).

Comparison of two specimens of about the same size from Cuba, one (Pl. 4, fig. *23*), ellipsoid, and one (Pl. 5, fig. *11*), with long ellipsoid ambitus nearly one third longer than its breadth, shows little or no conformity to two individuals (Pl. 5, figs. *15*, *16*), from Port Antonio, Jamaica, the larger of which is ovoid in outline, the smaller ellipsoid with slightly projecting ambulacra, and large actinostome. Of three young specimens also from Port Antonio, the two smallest (Pl. 5, figs. *12*, *13*), are ovoid in outline, while the third (Pl. 5, fig. *14*) is ellipsoid with a slight deviation in character towards a young specimen of the same size from Mauritius (Pl. 5, fig. *5*).

Profile views of the tests strengthen the opinion that variation in shape is not wholly due to disparity of age or locality. In two adult specimens of the same length, one from Barbados (Pl. 2, fig. *3*), the other from the Pacific (Pl. 3, fig. *5*), the shape of the profiles are exactly alike, with equally curved actinal and abactinal outlines. A third specimen (Pl. 4, fig. *9*), from Makemo Island

has the actinal surface on the anterior end rounded outwards, with the abactinal side in the apical region depressed. It is not unusual in large specimens to find the same features as are shown in a specimen from Gilbert Islands (Pl. 4, fig. 13), with its actinal side perceptibly arched, or as in specimens from the Pacific (Pl. 4, fig. *21*), and Cuba, (Pl. 4, fig. *24*), with straight tests and narrow posterior ends. The test seen from the anterior end facing the odd anterior ambulacrum (Pl. 4, figs. *5, 10, 14, 17, 22*), varies in outline from ovoid to spherical and frequently, as in Pl. 4, fig. *10*, one side is higher than the other.

Development of the Coronal Plates.

Plates 6, 7, 13.

The arrangement of the primordial ambulacral plates in each ambulacrum is the same as in the spatangoids, and follows the formula given in Lovén's Études; usually the succeeding two pairs or so are simple plates after which they are in groups of three of which the upper is the largest. This plate is somewhat broader at the median ambulacral suture; the second one, a demiplate, is wedged in between the first and third, the latter being quite low. In the adult these plates, (Pl. 13, fig. *5*), on the abactinal side are very low and about four times as broad as they are high. Each plate, except the largest one, has a double perforated pore, in the edge of the actinostome (Pl. 13, fig. *3*); the largest plate has three perforations, the one towards the oral plastron being open.

In the young from Port Antonio, with the test 5.90 mm. in length, the shape of the actinostome is nearly circular; there is a primordial plate in each interambulacrum (Pl. 6, fig. *1*); and the same condition obtains in a specimen from Makemo Island (Pl. 13, fig. *1*), the test of which measures 4.40 mm. in length.

In the adult the shape becomes a triangle with its horizontal side limiting the bivium, and the vertical side running between the right anterior interambulacrum and the right posterior ambulacrum; its anterior and left posterior corners usurp a part, or the whole, of the primordial plates in the right anterior and the left posterior interambulacra, *cf.* Pl. 7, a specimen from Mauritius, with test 37 mm. in length and also my earlier sketches in Lovén's Études (Pl. 9, figs, 82, 83). An adult specimen, 27 mm. in length, from Makemo Island shows (Pl. 13, fig. *2*) the way this reabsorption varies; all the primordial plates are still in place and but little diminished in height.

So far as I know the labium in the spatangoids undergoes little or no change in form, while in Echinonëus, even from a single locality, there is much variety; for instance in two young specimens from Port Antonio, 4.19 mm. (Pl. 6, fig. *2*), and 5.90 mm. in length (Pl. 6, fig. *1*), the labium is almost three cornered and shut out from the anal system by the first pair of interambulacral plates; while in one, 6 mm. long (Pl. 6, fig. *3*), the broad base of the labium borders on the edge of the anal system just as in a specimen, 4.40 mm. in length, from Makemo Island (Pl. 13, fig. *1*). In two adult tests of practically the same size, 22, 25 mm. in length, from Port Antonio (Pl. 6, figs. *5*, *6*), the labium of the former (fig. *5*) is T-shaped with its smaller end on the anal system, while in the latter (fig. *6*), only a small strip in the edge of the actinostome remains, the same as in a specimen of about the same size, 27 mm. in length, from Makemo Island (Pl. 6, fig. *8*).

The actinal interambulacral plates are nearly as high as broad. At the ambitus where the test is ellipsoid they are higher than when it is ovoid, and continue thus on the abactinal side.

The peculiar way in which the plates overlap in the median interambulacral suture is not fully shown in Pl. 13, fig. *4*. The apparent continuation of the ambulacra on to the interambulacral plates (Pl. 13, fig. *5*), may be simply impressions due to the attachments of soft parts.

Oral and Anal Systems.

Plate 15.

Among the specimens collected at Port Antonio, the smallest measures 3.70 mm. in length; the oral plastron is devoid of plates, its actinostome, measuring 1.18 mm. in diameter, and is nearly circular, becoming triangular by growth as described in the development of the coronal plates. When further developed and adult the oral plastron is covered with solid, glossy plates without tubercles, imperfect polygons or rectangles in form. They are laid in irregular curves (Pl. 15, figs. *2*, *3*, *4*, *6*), and could serve as an orbicular shutter; their function is possibly the same as that of the teeth.

Upon comparing the shape of the anal system in a number of specimens from the West Indian and Pacific regions I find an indefinite irregularity in the outline; as for instance two tests from Lord Howe Island and of same size (Pl. 15, figs. *3*, *4*), in the first (fig. *3*), the opening is large and irregularly ovoid, while in the other (fig. *4*), it is noticeably shorter, with its angular base or aboral end

towards the ambitus. In an adult specimen, with a test 27 mm. in length, from Makemo Island (fig. *2*), the anal system is elongated, ellipsoid, with pointed adoral and aboral ends; and in two other specimens (figs. *5*, *6*), 27 mm. long, from Mauritius, the opening in fig. 5 is broader with the aboral end pointed, while in fig. *6* it is more symmetrically ellipsoid. Two young specimens from Port Antonio, tests 6 mm. and 10 mm. in length, show the same diversity; one (fig. *8*), is smaller and an ellipsoid; the other (fig. *9*), with its aboral end running into a sharp point, has little or no similarity to a specimen from Florida (fig. *11*), which also differs from an adult individual from Barbados (fig. *12*); in the latter the opening of the anal system recalls that of the specimen from Mauritius (fig. *5*). In a specimen 29 mm. long from Bourbon (fig. *7*), the outline with its broad rounded aboral end, has no similarity to any of the other figures given on Pl. 15. This change in outline and size of the anal system, which is probably caused by the amount of resorption in the first six or seven pairs of interambulacral plates, makes the anal system valueless as a specific character.

The order in which the plates are arranged on the buccal and anal plastrons in other families of the spatangoids has hitherto been regarded as irregular and of slight consequence. The figures given on Pl. 15 of the anal plastron show a remarkable regularity in the grouping of the plates; about seven to nine of which are laid on the plastron adjoining the interambulacral plates with the largest ones in the adoral end slightly raised. The aboral end has three or more large plates with the addition of a number of small ones surrounding the anal outlet. In the specimens from the Pacific the largest plates on the plastron towards the adoral end, are separated at the median line either by a large plate, or a double row of rhomboidal ones, while in the West Indian specimens these plates are replaced by a number of long slender calcareous strips, which make the surface flexible. This is the only differential point I find between the Pacific and West Indian specimens, and it accords with Mr. Agassiz's statement, Revision, p. 334–335.

The Abactinal System.

Plate 14.

At first it was intended to limit this report to a few plates, and a more careful examination of the abactinal system was left for the future.

In a young specimen from Makemo, 4.40 mm. in length, interior view (Pl. 14, fig. *2*), none of the genital plates have received their pore, excepting a few madreporic perforations on the madreporite. Of the two posterior genital plates the one towards the right posterior interambulacrum is slightly larger than its mate; both are about as high as broad and in contact with the ocular plates in the bivium; of the two anterior ones the madreporic is the larger. Seen from the exterior (fig. *1*), the apex is slightly raised, carries a few miliaries and a small number of the glassy tubercles.

Another specimen 4.19 mm. in length, from Port Antonio (Pl. 14, fig. *3*), differs from the previous one only in the left anterior genital being slender, and the right posterior genital having pushed itself between the ocular plates of the bivium, which in fig. *2* are in apposition.

Of two specimens, one 12.5 mm. long from Port Antonio (Pl. 14, fig. *4*), the other 27 mm. in length (Pl. 14, fig. *7*) from Makemo, the genital plates correspond exactly to each other in form and size; the anterior plate being longer than the posterior which is the reverse of what is shown in figs. *2* and *3*; here the two large plates are posterior, with the larger one in the right posterior interambulacrum, while in figs. *4* and *5* these are in the left posterior interambulacrum. The system of the four genital plates are arranged in a square and are in contact; their form and that of the pentagonal shaped ocular plates are very similar to the figure of *Hemiaster expergitus* in Lovén's Études (Pl. 11, fig. *93*), and of *Periaster tenuis* in Agassiz's Panamic deep sea Echini (p. 210). In two specimens (Pl. 14, figs. *5*, *6*), from the Pacific, measuring 26, 27 mm. in length, one (fig. *5*) has very small genital pores, about one third the size of the other (fig. *6*); this may be due to sex; the glassy tubercles are larger, darker, and more numerous in fig. *5* than in fig. *6*. This variation is found in alcoholic as well as in dry specimens.

The Sphaeridia.

Plates 16, 17.

Thirty-three figures of the sphaeridia from tests of intermediate sizes varying from 10 to 34 mm. in length, and from various localities in the West Indian and Pacific regions, are given on Pls. 16 and 17. No two are exactly alike, neither do they show any specific characteristics; but some of them correspond in form to those of Maretia or Brissopsis, *cf.* Lovén's Études, Pl. 1.

An examination of the sphaeridia in Echinonëus shows their height to be greater in proportion to the size of the test in the smaller specimens than in those full grown. The largest sphaeridium of a young specimen, from Makemo Island, 10 mm. long, is 0.10 mm. in height; in another from Fakarava Island, 12 mm. in length, it is 0.13 mm., and a third from Barbados, with the test 26 mm. in length, has the highest 0.20 mm., while an adult specimen from Lord Howe Island 34 mm. in length or three times as long as the youngest from Makemo Island, has its sphaeridia only 0.16 mm. in height.

Among the material at the Museum I found only three sphaeridia to each ambulacrum, although Lovén's Études (Pl. 9, fig. 79), gives four. There are scarcely two alike from the same ambulacrum; some have an uneven papillate surface, but commonly they are almost smooth. The row of sphaeridia (Pl. 16, figs. *1–4*), taken from odd anterior, right anterior, left anterior, and left posterior ambulacra respectively of a specimen from Fakarava Island, 12 mm. in length, vary in form with no indications of specific characters. Of six sphaeridia (Pl. 16, figs. *5–8*), from two specimens from Lord Howe Island, 30 and 34 mm. in length, two (fig. *5*) from the odd anterior ambulacrum are 0.16 mm. high, one of them being spherical with a wavy outline, the other smooth and pointed at the top; one from the left anterior ambulacrum (fig. *6*) is depressed with flattened top; another from the left posterior ambulacrum (fig. *7*), has a spherical outline, slightly truncated at the upper end. Two others (fig. *8*), from the right anterior ambulacrum of a specimen measuring 30 mm. are 0.18 mm. high; one is unevenly cylindrical in outline, the other ovoid. This irregularity of form (Pl. 16, figs. *13, 14*), can be traced even in the young test measuring 10 mm. in length.

In ten figures from the different ambulacra (Pl. 17, figs. *1–6*), of two specimens, from Barbados, measuring 26 and 30 mm. in length, the height of the sphaeridia varies from 0.17 mm. to 0.20 mm. This variation which exists between the sphaeridia is further accentuated as shown in fig. *1* where the sphaeridium from the right posterior ambulacrum is ovoid with two points at the top, its companion being ellipsoid with a sharp upper end. There is still another form,

that of a one-sided sphaeridium (fig. *3*) from the odd anterior ambulacrum which contrasts with the circular chipped outline (fig. *4*) and its ovoid mate, from the left anterior ambulacrum. Dissimilarity is also observable (fig. *6*), where the first sphaeridium is ovoid and the other club-shaped; both came from the right anterior ambulacrum of a specimen 26 mm. long.

It is noticeable that the five figures on Pl. 17, figs. *7–9*, are not exactly like those on Pl. 16, figs. *1–4*, although the specimens came from the same place, Fakarava Island. It should, however, be observed that they were taken from two specimens, one 12 mm. the other 23 mm. in length.

Arrangement of the Tubercles and Scrobicular Circles.

Plates 24, 25.

De Loriol mentions the tubercles and scrobicular circles as specific characters.[1] In perfect specimens, on the actinal side near the actinostome in the interambulacral area, the primary tubercles may be for the most part without a scrobicular area, but surrounded by large glassy tubercles. In other specimens of the same size, from the same locality, the boss is deeply set on the test, and the scrobicular circles are transformed to open angular cells, with a small number of miliaries and a few minute glassy tubercles on their edges. (Pl. 25, fig. *9*.)

The primary tubercles on the actinal side are nearly uniform in size and arranged in horizontal rows. A few of the plates nearest the actinostome have a single line, after this each plate has two; in the region of the ambitus, and for some distance above, the tubercles run diagonally as well as horizontally, and they vary in number according to age. They are smallest in the odd posterior interambulacrum.

The seventh plate from the actinostome, including the primordial, in the left anterior interambulacrum of eight specimens from Port Antonio, measuring from 4.19 mm. to 17 mm. in length (with an interval of about two millimetres between each) is shown on Pl. 25, figs. *1–8*. In the smallest specimen, 4.19 mm. in length (fig. *1*), this plate is on the abactinal side, and has, besides a few miliaries, only two of the primary tubercles, one being towards the upper corner near the median line. In the next smallest, 6 mm. long, this seventh plate (fig. *2*) is on the actinal side, and has its third tubercle near the upper outer corner; all

[1] Two specimens from Mauritius, 36 and 37 mm. in length, resemble de Loriol's *E. abnormalis*, but the mamelon is without a perforation.

three are grouped in a triangle with the base upwards. These three first primaries are recognizable in fig. *3* (8 mm.), and fig. *4* (10 mm.), the latter having an increase of two primaries in the lower part, one being towards the outer side, the other near the median line. In fig. *5* (12 mm.), the seventh plate is not quite normal, but it shows the same regularity. When a length of about 15 mm. (fig. *6*) is reached, the upper row has four primaries, one of the new comers being near the outer margin, the other, which is the smallest near the median suture. In a test of 17 mm. (fig. *7*), and an adult of 26 mm. (fig. *8*), there is no increase of the primaries, but they are arranged as previously described. The miliaries vary in number. The glassy tubercles are minute, few, and frequently absent.

While there are only four of the primary tubercles in the upper row in these specimens, Pl. 25, figs. *1–8*; when the test is broadly ovoid with a length of 35 mm. or so, they have gradually increased to eight or more.

A comparison of the primary tubercles on the ambulacrum in specimens of various sizes and different localities shows a regular order in their appearance. The odd anterior ambulacrum was selected for illustration, and in the extensive material examined from Port Antonio, there was no deviation so long as the specimens were normal. The smallest specimen, 6 mm. in length (Pl. 24, fig. *1*), has two rows of primary tubercles, one on each side of the ambulacrum adjacent to the ambulacral pores. The first primary of the next line, the third, has its seat in front of the fourth tubercle from the actinal system as shown, Pl. 24, fig. *1–7*. This third row in fig. *2*, test 8 mm. long, curves towards the left side of the ambulacrum, to make room for the fourth which commences on the right side near the second tubercle of the third row, as seen in fig. *3*, a test of 9.5 mm., and fig. *4*, test 11 mm. long. A fifth row has its first tubercle above or close to the third primary of the fourth line, as in two specimens, 16 and 18 mm. long, figs. *5* and *6*. The latter specimen (18 mm.) has the sixth or last row to the right of the fifth, beginning at the right of the first tubercle in the fifth row. Some of the central rows extend only to the actinal and abactinal region of the ambitus. The odd anterior ambulacrum of a test 27 mm. long, from the Pacific (fig. *7*), shows exactly the same number of rows and order of grouping in the primary tubercles as is seen in those from Jamaica.

The glassy tubercles are mostly ovoid, with their lower half in the test, flattened at the top with corrugated sloping sides, armed with small sharp points (Pl. 25, figs. *11*, *12*). They are either colorless, or of a blackish tint, until freed from the test when they become transparent.

The Pedicellariae.

Plates 18–23; Plate 26, figs. *16–19, 30, 31*; Plate 27, figs. *12, 13, 23, 24, 35, 36, 43, 44*.

How great the variation of shape can be in pedicellariae of the same kind, taken from the same specimen, but from different parts of the test, is shown in the illustrations (Pls. 18–23) which are few when compared with the material available. To distinguish which valve of the three in any one pedicellaria is meant, since they are not of equal height, or the same form of loop, I have used in addition to Mortensen's comprehensive terminology, the letters A, B, C; A, denoting the highest, C, the lowest, and B the intermediate valve.

The tridentate pedicellariae are few in number, and found only on the actinal side of the test, near or a short distance from the oral and anal systems. Of three valves from the same pedicellaria (Pl. 18, figs. *1–6*), from a specimen 34 mm. long, from Lord Howe Island, no two of them have outlines exactly alike. The blade in valve A (fig. *2*), at the upper part is ellipsoidal, and does not correspond to valve B (fig. *3*), where it is circular; while in valve C (fig. *5*), it is slightly pointed. We find the same irregularity in the base, which either slopes, or has a sharp prolongation on the right or left side close to the neck. A valve of another pedicellaria (Pl. 18, figs. *10, 11*), has no indication of the articular loop, and the blade is possibly broken. Presumably it is a young tridentate pedicellaria.

For uniformity one of the series valve B, was chosen for comparison. Three such valves (Pl. 18, figs. *7, 9*), from a specimen 15 mm. long from Makemo Island, were taken respectively from near the actinostome in the odd posterior interambulacrum, from the odd anterior ambulacrum, and from the right anterior interambulacrum. The obvious difference in the form of the blades, which vary from a triangular point to a round top, in the variation in number of lateral teeth from 11 to 15 in each blade, and in the shape of the neck and bases, is most striking. They are very unlike those on Pl. 20, figs. *8, 10–13*, also from Makemo Island specimens. I find no specific identity between two valves (Pl. 20, figs. *8* and *10*), from the same specimen, 10 mm. long; one valve from the aboral end of the anal system, the other from midway between the actinostome and the ambitus, in the right posterior interambulacrum. In one of these the blade and base are of nearly the same height, while in the other the outline of the base is rounded, the long neck abruptly narrowed, and the blade short with indications of lateral teeth. In valve C (fig. *11*), from another specimen 11 mm. long, these lateral teeth are very conspicuous. The same striking difference is observ-

able in a valve B (fig. *12*), and a valve C (fig. *13*), from a specimen 18 mm. long; in the former the blade and base are of about the same size, while in the latter the base is diminished in size and deltoid in shape.

When selecting valves for illustration from a number of specimens from Fakarava Island, "Albatross" Exped. 1899–1900, I decided, after some hesitation, upon figures to show the greatest extremes in form; thus Pl. 19, fig. *5*, valve B, with a triangular base, has a remarkably long neck and minute blade without serrations, and this has little similarity to a valve A (Pl. 19, fig. *2*), with serrations and large lateral teeth, or to a valve B (fig. *3*), with its large ovoid blade, comparatively short neck, and rounded outline of the base, which in valve C (fig. *4*), is irregular. In connection with these it is interesting to note that in a specimen from Barbados, 26 mm. long, I find some of the tridentate valves (Pl. 19, fig. *7*), showing the character of those from Fakarava Island (Pl. 19, figs. *1–4*). The only dissimilarity is in the outline of the base, which in the specimen from Barbados, is armed close to the neck on both sides with large prolonged points.

Between three specimens 11, 12, and 13 mm. long, and one 19 mm., all from Fakarava Island, I should not expect to find great dissimilarity, but valves A, B, C, from the same pedicellaria in the smallest specimen, have broad rounded blades with large lateral teeth and stout symmetrical bases, which including the articular loop, are as long as the blade. Their form has no similarity to a valve B (Pl. 20, fig. *5*), from midway between the actinostome and the ambitus in the right anterior interambulacrum, or to another valve B (Pl. 20, fig. *6*), from near the actinostome in the right anterior interambulacrum, which has a long deltoid base, and short triangular blade; neither is it like another valve B, (Pl. 20, fig. *7*), from the adoral end of the anal system. Even fig. *9*, a valve B, with its well-marked lateral teeth differs from the others.

The material from Port Antonio shows still further diversity as seen in a comparison of nine valves of the series B, one of them (Pl. 23, fig. *12*) from the odd posterior interambulacrum, actinal side, near the ambitus, with its broad neck which gradually unites to the blade, contrasts with one (fig. *13*) from the aboral end of the anal system, in which the blade is nearly circular. Both valves are of equal height, and from the same individual, measuring 25 mm. in length. I find another case of a valve (fig. *14*) from the adoral end of the anal system of a specimen 26 mm. long, where the remarkably large base is almost square, the blade broad and short, and ending in a sharp point; this is quite unlike a valve (fig. *15*), from the left posterior interambulacrum near the

actinostome from a specimen 28 mm. long, which has the edge of its long neck bent inward like a collar, and which in turn contrasts to figs. *9–11*, Pl. 23. The first one from a specimen measuring 11 mm. in length, and the two latter from one 20 mm. long. In a young specimen of 4 mm., the valve B (fig. *1*), from the anal system, and (fig. *2*), from the right posterior ambulacrum, near the actinostome, already have a difference in their shape.

It should be noted that tridentate pedicellariae (figs. *17–26*) were owing to insufficient space on the preceding plates placed on Pl. 22. The specimens were from the Paumotu Islands, South Pacific, and from the West Indies, and the figures readily show their diversity in shape.

The ophicephalous pedicellariae are the most numerous, especially on the abactinal side, and they vary the least in form. Three valves, same pedicellaria (Pl. 21, figs. *3*, *4*, *6*), from the left posterior interambulacrum, of the actinal side of the ambitus, from a specimen 34 mm. long, from Lord Howe Island can be regarded as typical; but a large number deviate as will be seen in valve C (fig. *7*), and valve A (fig. *8*), from the actinal side of the ambitus in the right posterior interambulacrum, and especially in valve A, with its long slender neck and articular loop pointed at the lower end. Of course a difference in shape is to be expected between pedicellariae from the abactinal side of the test, or near and on the apex, and those from the actinal side. This is shown in two valves, B (fig. *9*), and C (fig. *10*), of the same pedicellaria, from near the apical system of a 30 mm. specimen when compared with the figures referred to above. In valve B which is practically of the same height as that shown in fig. *4*, the blade with a broad apophysis passes into the base almost without any neck; the articular loop is stout and sharp pointed at its lower end; the articular teeth are wide, and the articulation surface slopes to the left where the loop is thickest; this is reversed in the other (fig. 4), where it slopes to the right; this reversal is a common occurrence. Two valves, B and C, in height 0.16 mm., from the apical system, of a specimen 11 mm. long, from Fakarava Island (Pl. 21, figs. *11*, *12*), do not present any great deviation from two others, B and C, 0.21 mm. in height from the actinal side of a specimen 15 mm. long, from Makemo Island, (figs. *13*, *14*).

Of three valves, the same pedicellaria from the right posterior ambulacrum, near the anal system, from a specimen 30 mm. long, from Barbados (Pl. 21, figs. *15*, *17*), the blade has lost its discoidal form, and passes into the base almost without any neck. The loop is that of an ophicephalous pedicellaria, but the base and blade are exactly those of a tridentate form, and this may be noted even in valves (figs. *18–20*), from the abactinal side up to the apical system.

One might regard this as a specific character for the West Indian species, but it is not characteristic of those from Jamaica. Two valves, A and B (Pl. 23, figs. *3*, *4*), from the odd posterior interambulacrum, near the anal system, in a young specimen 4 mm. long, from Port Antonio, resemble those of a typical ophicephalous pedicellaria.

The globiferous pedicellariae were found only near the ambitus, and on the abactinal system in the two specimens from Lord Howe Island, and in a small specimen from Fakarava Island; besides these there were some near the summit in the two individuals from Barbados, and in the specimens from Jamaica. These pedicellariae (Pl. 22, figs. *1–16*, Pl. 23, figs. *5–8*), are essentially alike in the different specimens, although they vary more or less in outline.

In three valves of the same pedicellaria, from the left anterior ambulacrum, on the actinal side toward the ambitus, the pointed blade is nearly as long as the base (Pl. 22, figs. *3–6*), with twelve strong lateral teeth on each blade, except C, which has only eleven. In other valves examined, the number of the lateral teeth in A and B, vary from nine in the smallest to thirteen in the largest, valve C generally having one less. From the right posterior interambulacrum, at the ambitus, in valves A and C (figs. *8*, *9*), height 0.26 mm., the blades are round at their upper ends, and about one third the length of the base, while in two other valves B and C, 0.34 mm. in height (figs. *10*, *11*), from towards the apical system, the blades are longer, and the bases broader at the articulation surface. Another (fig. *12*), valve B, height 0.32 mm. from near one of the genital plates, has assumed the form of those on the actinal side. All these pedicellariae came from the same specimen, 34 mm. long, from Lord Howe Island, N. S. Wales.

When the distance between the localities, and the difference in length of the two specimens (one 34 mm. from N. S. Wales; the other 19 mm. long, from Fakarava Island) is considered, it is singular that the pedicellariae do not apparently show any real differences (see figs. *13*, *14*, two valves, A and B, from the right posterior interambulacrum of the latter). Attention should be called to the slenderness of the valves (Pl. 22, figs. *15*, *16*), in a specimen 30 mm. long, from Barbados, when compared with a valve of a 4 mm. specimen from Jamaica, (Pl. 23, fig. *5*); in the latter it is nearly triangular, with a minute blade and rounded base. This difference might be considered important if another valve (Pl. 23, fig. *6*), from the same part of the ambitus and from the same Jamaican specimen was not shaped like those from Lord Howe Island and if it was not also unlike two valves (figs. *7*, *8*), in a specimen 5 mm. long, from Jamaica.

The articular loop in valve A is short, straight, and generally has two foramina; in valve B, the loop is prolonged either at the right or left side (Pl. 22, figs. *4*, *14*), with a single foramen, while in valve C, the articulation surface slopes downward, and the loop is rudimentary.

The triphyllous pedicellariae were found only in the Jamaican specimens (Pl. 23, figs. *16*, *17*), and mostly in the ambulacra near the actinostome. Even in the adult specimens they are very small, 0.04 mm. in height; the bilobed blade constitutes the largest part of the valve.

A comparison of the height of the pedicellariae to the length of the test from which they were taken, shows that in young specimens they are proportionally larger than in the adult. Where a tridentate pedicellaria is 0.13 mm. in height on a 4 mm. specimen, it is only 0.51 mm. from a test 34 mm. long.

The stalk of the pedicellariae differ in form on different parts of the test. One stalk (Pl. 26, fig. *31*), of an ophicephalous pedicellaria, near the actinostome, from a specimen 18 mm. long from Makemo Islands, with its long rod, ending in a head, is similar in form to one of the same order from the actinostome of an adult specimen (Pl. 27, fig. *36*), from Jamaica. In a specimen 34 mm., from Lord Howe Island, on the abactinal side towards the apex (Pl. 26, fig. *19*), the stalk is thicker, and without a head, corresponding to one (Pl. 27, fig. *13*), on the abactinal side of a specimen 23 mm. long, from Fakarava Island.

The stalks of the globiferous pedicellariae have peculiar processes, similar to those of some spatangoids, as figured by Mortensen "Ingolf" Exped. Ech., pt. 2, pl. 17, 18). Otherwise they show little diversity, though one (Pl. 26, fig. *17*) from near the apical system of a Pacific specimen, 34 mm. long, is more solid than some others. The latter are shown on Pl. 27, one (fig. *24*) from the abactinal surface of a specimen from Barbados, 30 mm. long, and another (fig. *44*) from a Jamaican specimen only 4 mm. long.

The Spicules of the Tube-feet.

Plate 28, figs. *1–14*.

No special difference was found in the tube-feet (Pl. 28, figs. *1–14*), though a large number of specimens from the Pacific and also the West Indies were studied. They all agree in having a disk composed of three plates, but the number may vary, as Lovén has shown (Pourtalesia, Pl. 11, fig. *117*). In some the periphery of the plates is lobed (Pl. 28, figs. *5*, *6*, *13*), but usually it has an irregular ragged outline, as seen in Pl. 28, figs. *8*, *9*, *12*, *14*; figs. *8* and *9*

are from West Indian specimens, figs. *12* and *14* from specimens taken in the Pacific.

At the smaller inner end, the plate (Pl. 28, figs. *5*, *6*, *12*) is prolonged slightly beyond the adjoining surface in some of the Makemo and Jamaican specimens. This is quite different from what is seen in a Barbados specimen, where the projection can easily be recognized, though placed in a reëntrant curve (Pl. 28, figs. *8*, *9*). In another specimen from Fakarava Island the inner end of the plate (Pl. 28, fig. *14*) is almost straight.

Close to the base of the disk on the lower side there is a set of two or more layers of yoke-shaped spicules (Pl. 28, figs. *2*, *3*, *7*); these are nearly straight with a few small perforations on the inner side of the spicule. The tube-feet on the actinal, and on the greater part of abactinal side, seem to be without any other spicules, but in some of the tube-feet near the ocular plates a number of slender rods (fig. 10) were found; the disk plates were only rudimentary.

The changes in the appearance of the disk may be due as much to their position on the test as to growth, as may be seen in three Jamaican specimens. In a specimen 25 mm. long the tube-feet of the actinal side, near the mouth (fig. *5*) with disks 0.22 mm. across, are very different from those near the apical system (fig. *6*) with disks only 0.14 mm. wide. But in much younger specimens, the first formed tube-feet (fig. *4*) which are found close to the mouth, are similar to the newly formed ones near the ocular plate. Apparently the difference between figs. *11*, *12*, from the actinal side of the test, and fig. *13*, from near the ocular plate, in the specimen from Makemo, is due to difference in age.

The Peripodia.

Plate 28, figs. *15–24*.

A comparison of the peripodia in a number of specimens, both young and adult, from various localities, does not reveal any reliable specific character, as the shape of the peripodium changes in form, size, and position on the different plates.

Of four peripodia (Pl. 28, figs. *15–18*), from a specimen 34 mm. long, from Lord Howe Island, the first one at the edge of the actinostome (fig. *15*), is singly perforated, and placed vertically on the plate. The fifth from the actinostome, (fig. 16), with its great horizontal perforations, is the largest; the smallest is attached to the ambitus, and is placed diagonally on the outer part of the plate. These and one of the youngest peripodia near the ocular plate, with its oval

form and large perforations illustrate the variation that obtains in the same specimen.

The open rectangular shape of the first pore in the edge of the actinostome, in a specimen 37 mm. long, from Mauritius, while not of common occurrence, is far from exceptional in specimens from other localities.

Any peripodium would have sufficed to show the variation in shape, but for uniformity the fifth one (Pl. 28, figs. *16*, *20*, *22–24*), in the odd anterior ambulacrum of five adult specimens from the Indian, Pacific, and West Indian regions was selected.

The Spines.

Plate 26, figs. *1–15*, *20–29*; Plate 27, figs. *1–11*, *14–22*, *25–34*, *37–42*.

There are only two kinds of spines; one on the primary tubercles, the other on the miliaries (Pl. 26, figs. *1–15*, *20–29*; Pl. 27, figs. *1–11*, *14–22*, *25–34*, *37–42*). Those of the primaries are without serrations, some of them on the actinal side, especially those near the oral and anal systems in adult specimens, reach a length of three millimetres or so. The radioles on the abactinal side become stouter with either a blunt or pointed end, and gradually diminish in length until in the apical system they measure less than half a millimetre, and on the madreporic plate not quite one fourth of one.

I have been unable to find any difference between the radioles of specimens from the Pacific or the West Indian regions, excepting a slight individual variation. The base on the longer spines agrees in being higher at one side and thus giving the milled ring a sloping line when seen in profile. The sections of these spines given on Pls. 26, 27, show either about nine or twelve rods in each; exceptionally one or more of these rods (as seen in Pl. 26, figs. *2*, *3*; Pl. 27, figs. *8*, *9*, *30*, *38*, *40*), is serrated near the base, or for the whole length. The various forms in the outline of the sectional figures are due to the shape of the rods, which in some spines are semicylindrical, while in others they are much more prominent and deeply separated from each other.

Radioles of the same length, and from the same plate may differ noticeably from each other according as to whether they have a pointed or a rounded tip. This is shown by two spines (Pl. 26, figs. *6*, *7*) from the ambitus, left anterior interambulacrum, of a Pacific specimen, 34 mm. long. A similar difference is also easily seen by comparing two spines from a Barbados specimen, 30 mm. long; one (Pl. 27, fig. *18*) from the ambitus, right anterior interambulacrum; the other (Pl. 27, fig. *17*) from the odd posterior interambulacrum near the anal system.

The spines of the miliaries are serrated, smaller in size and of even diameter up to the distal end where they thicken, and each rod ends in a sharp point. Those found on or close to the actinostome are nearly one millimetre in length, and diminish until in the apical system they are very minute. There are some even on the anal system. The only other form seen was in a Fakarava Island specimen (Pl. 27, figs. *1*, *2*), where near the actinostome a few of them are lanceolate. The serrations on these spines from near the actinostome, frequently stop short of the distal end in specimens from the Barbados (Pl. 27, fig. *15*) and Jamaica (Pl. 27, fig. *25*).

The Lantern and Auricles.

Plate 11, figs. *1*, *2*, *7*, *8*; Plate 12.

Of the various specimens brought from Port Antonio, Jamaica, a small number were nearly, or but a little over, five millimetres in length; only four, provided with a masticatory apparatus, were under this measurement. Considering that they had been a few days in alcohol, when the preparations were made, they showed the various parts, including the pigmented sack that holds the lantern (Pl. 11, figs. *1*, *2*), very well. The lower end of this sack is probably joined to the buccal membrane by a small neck; it contains a few calcareous particles close to the teeth (Pl. 11, fig. *4*). In just what manner this sack passes the pentagonal muscular band of the summit of the lantern, and whether it is connected with the oesophagus which goes through its centre where the compasses meet, could not be ascertained, as the diameter of the lantern was only 1.24 mm. and too fragile for dissection. The calcareous parts of the whole apparatus are fairly solid, and not quite so delicate as the valves of the pedicellariae. To each of the primordial interambulacral plates are attached a pair of strong muscles (Pl. 11, fig. *2*), each with two branches at the upper end, one of which is fastened to the compass, the other apparently to the brace. The lower end of each half pyramid is also connected by two muscles to the rudimentary auricle, and its ambulacral plate. After being denuded of their spines, the smallest specimens having a lantern, were only 3.70 mm. in length (Pl. 11, fig. *1*), and the largest 4.25; in the latter (Pl. 11, fig. *8*), the volume of the dental apparatus filled about one sixth of the space inside the test. The next available size was 5.16 mm. in length (Pl. 11, fig. *9*), and lacked not only the masticatory apparatus, but the auricles also (Pl. 11, fig. *10*).[1] It seems very unlikely that

[1] The statement (Amer. journ. sci., 1909, ser. 4, **28**, p. 490) that the small auricles are present is erroneous.

it was shed, or liberated spontaneously. A resorption similar to that which occurs in some parts of the test, appears more probable. In what manner the oesophagus follows this change, and from a tiny tube inserted at the centre of the pyramids, becomes funnel-shaped at its lower end and fastened to, or near the pentagonal nerve and water-vascular canal, which remains permanent on the buccal membrane, is a matter of conjecture.

The auricles are disconnected, minute and flattened to the ambulacral plate (Pl. 11, figs. *5*, *6*). The largest part of their surface is covered by a muscular attachment. Their resorption is probably contemporary with the dental parts.

The pyramids (Pl. 12, figs. *4–8*), have deep foramina, a little over one third of the height, are slightly concave on the inside, and somewhat keeled on the outside parallel to the tooth. The adjacent edges are thin, and the corrugations absent. The outline, narrow at the summit, and the lower tapering end, differ considerably from the figure of Discoidea, given by Hawkins (Geol. Mag., new ser. Decade V. April, 1909, 6, p. 148–152, pl. 6). The compass (Pl. 12, figs. *11*, a. b), is distinctly articulated, and when seen in profile curves at the outer end.

The scapula-shaped epiphyses without being united to the pyramid (Pl. 12, figs. *1*, *12* a. b), follow the brace horizontally, and are held in place by connecting tissue; this could have been seen (Pl. 1, fig. *1*), if its minuteness had not prevented removal of the membrane, which would have displaced the parts. The braces do not show any special peculiarity in form.

Seen in profile the strong tooth (Pl. 12, figs. *9* a. b. c), is distinctly curved with a high keel on the inner face and a shallow groove on the outer.

The Alimentary Canal.

Plates 8–10, Plate 11, figs. *8*, *9*.

Although the Jamaican specimens were in very good condition for examination, having been in alcohol only a few days, still several important points of anatomical detail remain for future study on living specimens, and the figures given are limited to the alimentary canal, and the associated reproductive organs. The oesophagus rises vertically from the buccal membrane in a thin transparent funnel-shaped tissue, which tapers quickly into a tiny tube (Pl. 10, fig. *5*), and extends nearly half the height of the test, where close to the insertion of the actinal intestinal appendage it enters the actinal loops of the alimentary canal

(Pl. 10, figs. *1*, *2*, *4*, *5*), at a sharp angle. In the young, the oesophagus nearly reaches the madreporic plate, with the axial organ on its right side (Pl. 10, fig. *3*, Pl. 11, figs. *8*, *9*). It is held in place with the flat almond-shaped actinal intestinal appendage by a mesentery which is fastened to the abactinal part of the left anterior interambulacrum, close to the odd anterior ambulacrum; this mesentery divides the upper anterior cavity of the test into two open chambers (Pl. 10, fig. *4*). The free vertical edge of this mesentery is slightly folded near the genital ducts, broadening as it comes to the buccal membrane where it is apparently connected with the nerve-ring by what may be the lower part of the axial organ (Pl. 10, fig. *5*). A nerve ascends along the free edge of the mesentery and shortly before reaching the apex, connects with the axial organ.

In young specimens, test without spines, 5 mm. long (Pl. 9, figs. *4*, *5*, *6*), the general shape of the alimentary canal is nearly like that of the adult. The actinal loop is broad where the oesophagus and actinal intestinal appendage are inserted (Pl. 8, figs. *3–5*, Pl. 9, figs. *1*, *2*), and continues so until in its curve backward and to the right, it passes the right posterior ambulacrum. There it gradually narrows, until it reaches the anterior margin of the right anterior interambulacrum where it curves abruptly upward and becomes the abactinal loop, following the ambitus on the right side of the test. When it reaches the odd posterior interambulacrum, it broadens and has a reëntering curve for passing the rectum (Pl. 8, figs. *3–5*), in front of the median line; its outer edge being closer to the test, than that of the actinal loop. In the left anterior interambulacrum, the abactinal loop suddenly tapers (Pl. 8, figs. *4*, *5*, Pl. 9, fig. *2*), passes upward close under the reproductive organs, and becomes tubular. It is held by mesenteries to the abactinal median line of the odd posterior interambulacrum clear to its end at the anal plastron. Posterior to the oesophagus from the buccal membrane (Pl. 10, fig. *5*), there rises a narrow mesentery which soon turns a half spiral, with its broadest surface attached to the inner edge of the left half of the actinal loop, and to the actinal intestinal appendage; while the narrow part is fastened to the inner edge of the right half of the actinal loop (Pl. 8, fig. *3*, Pl. 9, fig. *1*), as far as the odd anterior ambulacrum. Another mesentery is attached in a similar way to the abactinal loop of the alimentary canal (Pl. 10, fig. *4*), but is connected with some of the plates of the apical system.

Close to the left anterior inner side of the actinal loop, on the mesentery is a brownish pigmented band (Pl. 8, fig. *3*; Pl. 9, fig. *1*), leading from the insertion of the oesophagus, and extending posteriorly. This is probably the accessory intestine.

The tissue of the intestines is generally highly pigmented and smooth, but sometimes contracted with peculiar regularity into surface folds, as seen in Pl. 10, fig. *9*. The rectum (Pl. 10, fig. *10*), in all the specimens examined was contracted lengthwise in long irregular creases.

Satisfactory figures of the nervous and water-vascular systems (Pl. 10, fig. *7*), were not obtained, though the ampullae appear to be bilobed, twice as long as wide, and pigmented (Pl. 10, fig. *8*).

The reproductive organs (Pl. 8, fig. *2*; Pl. 10, figs. *1*, *2*), are lacking in the posterior interambulacrum, but show no special peculiarity in their structure.

Micropetalon purpureum A. Agassiz and H. L. Clark.

Plates 29–31.

Unfortunately there is only a single specimen of this species which, although 17 mm. in length may not be fully adult. The general aspect and some of the details are those of Echinonëus. The broad ovoid ambitus, large triangular oral, and oblique anal apertures, recall the specimen of Echinonëus, 16 mm. long, from Florida (Pl. 5, fig. *17*).

On comparison with a young Echinonëus, 4.40 mm. long, (Pl. 3, figs. *1*, *2*, Pl. 13, fig. *1*, Pl. 14, figs. *1*, *2*, Pl. 15, fig. *1*), from Makemo Island, I find the test frail in both, the ambulacra flattened, and the breadth of the interambulacra at the ambitus in the bivium broader than in the trivium. In Micropetalon the adoral end of the anal opening inclines towards the left posterior ambulacrum, but this may be an individual peculiarity. The size and grouping of the plates on the anal plastron are precisely similar to the same in the young Echinonëus, but being further advanced in age, the anal system has acquired on each side, two additional interradial plates. The oral membrane in each is overlaid with minute calcareous plates, radiating towards the centre. Of the genital plates, three are of about the same size, while the left anterior is smaller. In Micropetalon the genital pores are present, which is not the case in the young Echinonëus. The ocular plates in the bivium are in contact in Micropetalon exactly as in the Echinonëus from Makemo.

The primary tubercles are comparatively few in number, and well separated, being grouped, beginning at about the fourth plate from the actinal system, in two horizontal rows on each plate, or diagonally over the test; each of the last four or more of the abactinal interambulacral plates has only one of these tubercles.

Like the young Echinonëus (Pl. 24, figs. *1*, *2*), Micropetalon has only three series of primary tubercles in the odd anterior ambulacrum. The first tubercle

of the inner series in Echinonëus usually appears first just in front of the fourth tubercle (from the edge of the actinal system) of the outer row; but in Micropetalon it is in front of the second. The mamelon is without perforation, the boss slightly raised, and the scrobicular circle indistinct. Of glassy tubercles there are only a few, mostly near the abactinal system.

Upon comparing the arrangement of the coronal plates in a specimen of Echinonëus, 5.90 mm. long, from Jamiaca (Pl. 6, fig. *1*), with that of Micropetalon (Pl. 30), I find a notable agreement; and considering the difference in size, it is remarkable that there are nearly the same number of plates in the radii of both.

There were probably three sphaeridia in each ambulacrum, in Micropetalon; those seen were pear-shaped. Of the pedicellariae I found only the ophicephalous, and these show little diversity in form and reveal no special characters. As in Echinonëus, a few spines near the actinal system have serrations which do not continue fully up to the distal end, and the longer spines also vary in having nine or more rods.

One of the notable points is the form of the spicules in the actinal tube-feet; there are four disk plates in each, with yoke-shaped spicules at their inner margins, while the outer edge of the disk generally has a ring of slender spicules slightly bent at both ends. At the ambitus and on the abactinal side near the ocular plates the basal disk has diminished in diameter to about 0.11 mm. with the four disk plates still less developed.

What may especially separate Micropetalon from Echinonëus, is the small low boss of the primary tubercles, that leaves greater intermediary space; while the absence of the thick glossy plates on the oral membrane and the flush poriferous zone with the minute ambulacral pores at the ambitus[1] suggest the retention of juvenile characters. The largest pores are in the primordial ambulacral plates, and one or two of the succeeding plates, and are vertically placed; the smallest are arranged diagonally at the ambitus, with a different form of peripodium and of pore opening, which are, however, different from those on the abactinal side towards the ocular plate where the pores are nearly horizontal. The resemblance to Echinonëus and the difference from the adult of that genus which the ambulacral pores of Micropetalon show, are well brought out in the figures (compare Pl. 28, figs. *15–18*, Pl. 29, figs. *9–12*).

One specimen of this species was taken during the 1902 cruise of the "Albatross" at Station 3847. Off Lae-o Ka Laan Light, Molokai, Hawaiian Islands, N. 64° 30′, W. 23′. 23–24 fms. bottom of sand and stones.

[1] These were overlooked when the specimen was first studied (Bulletin M. C. Z., 1907, **50**, p. 251).

LIST OF SPECIMENS.[1]

Echinonëus cyclostomus Leske.

Number of specimens	*Length of test in millimetres*	*Condition*	*Data*
4	largest nearly 30	Dry	Hawaiian Islands
8	13, 15, 16, 19, 20, 22, 26, 27	"	Pacific ?, 1863. J. G. Anthony
4	13, 14, 15, 18	"	Kingsmills Islands, Gilbert Islands. A. Garrett
1	20	"	Kingsmills Islands
3	largest about 40	"	Society Islands
7	4, 40, 10, 12, 14, 15, 18, 27	Alcoholic	Makemo, Paumotu Islands, Oct. 21. "Albatross" Exped. 1899–1900. U. S. Nat. Mus. (5), Mus. Comp. Zoöl. (2)
5	11, 12, 13, 19, 23	"	Fakarava Island, Paumotu Islands. Oct. 12, 1899. "Albatross" Exped. 1899–1900, U. S. Nat. Mus. (3) Mus. Comp. Zoöl. (2)
4	6, 13, 14, 16	Dry	Easter Island, Chile. Dec. 1904. "Albatross" Exped. 1904–05. U. S. Nat. Mus. (3), Mus. Comp. Zoöl. (1)
1	20	"	Australia
2	30, 34	"	Lord Howe Island, New South Wales (Littoral)
2	27.5, 28	Alcoholic	Mauritius, Oct. 13, 1873. Nicholas Pike
2	36, 37	Dry	Mauritius
9	5, 8, 9, 11, 15, 26, 28, 29, 31	"	Mauritius. Mrs. Luckock
2	17, 28.5	"	Bourbon
1	7	"	Mujeres Island, Yucatan. W. Stimpson
1	16	Alcoholic	Florida, Carysfort Reef. 1868, L. F. de Pourtalès
2	20	Dry	West Indies
2	17, 20	"	Cuba, 1859
1	11	Alcoholic	Havana, "Blake," 1877–78
1	26	Dry	Jamaica, Hitchcock
144	3.70–28	Alcoholic	Port Antonio, Jamaica. March, 1909, H. L. Clark. Mus. Comp. Zoöl., U. S. Nat. Mus.
29	6–20	Dry	Port Antonio, Jamaica. March, 1909, H. L. Clark
2	10, 15	"	Hayti
4	12, 14, 16, 18	"	Antilles, 1859
1	14	"	St. Thomas
2	26, 30	Alcoholic	Barbados (?) U. S. Eclipse Exp. to West Africa 1889. U. S. Nat. Mus.

Micropetalon purpureum A. Agassiz and H. L. Clark.

1	17	Dry	Off Lae-o Ka Laan Light, Molokai, Hawaiian Islands. "Albatross" Exped. 1902. U. S. Nat. Mus.

[1] All the specimens are in the collections of the Museum of Comparative Zoölogy and the U. S. National Museum.

SYNONYMICAL LIST.

ECHINONÆUS Van Phelsum.

1774. Van Phelsum, Brief Zeelglen, p. 32.

E. CYCLOSTOMUS Leske.

1778. Leske, Addit. Klein, p. 109, pl. 37, fig. 4, 5.
1790. Gmelin, Syst. Nat., **1**, pt. 6, p. 3183 (*Echinus*).
1816. Lamarck, Anim. sans Vert., **3**, p. 18.
1819. Blainville, Dict. Sci. Nat., **14**, p. 196.
1825. Gray, Thomson's Ann. Phil., **10**, p. 429 (*Echinanaus*).
1834. Blainville, Actinologie, p. 212, pl. 16, fig. 5.
1835. Agassiz, Mém. Soc. Sci. Nat. Neuchatel, **1**, p. 187.
1842. Desor, Agassiz's Monog. Échin. Galérites, p. 43, pl. 6, fig. 13–15.
1847. Agassiz, Ann. Sci. Nat., ser. 3, **7**, p. 143.
1855. Gray, Catal. Rec. Echin. Brit. Mus., p. 32.
1857. Desor, Synop. Échin. Fossiles, p. 197, pl. 27, fig. 1–3.
1862. Dujardin et Hupé, Échin., p. 545.
1872–73. A. Agassiz, Rev. Echini, p. 117, 550.
1874. Lovén, K. Svenska Veten. Akad. Handl., **11**, no. 7, pl. 9, fig. 79–82.
1883. Loriol. Mém. Soc. Phys. Genève, **28**, no. 8, p. 38, pl. 5, f. 3–6.
1894. Anderson, Journ. Asiatic Soc. Bengal, **63**, p. 194.
1895. Sluiter, Konin, Zoöl. Genoot. Amsterdam, Bijdr. Dierkunde, aflev. 17–18, p. 73.
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1899. Anderson, Rept. Marine Surv. India, 1898–99, p. 16.
1907. Mortensen, Danish Ingolf-Exped., **4**, pt. 2, p. 184, 193.
1911. Westergren, Ante, p. 44.

E. ovalis Linné.

1753. Linné, Mus. Tessin, p. 114 (*Echinus*).
1758. Seba, Locup. Rerum Nat. Thes., **3**, pl. 10, fig. 7, pl. 15, fig. 30, 33, 34. (*Echinus.*)
1771. Knorr, Delic., pl. D. I., fig. 11 (*Echinus*).

E. minor Leske.

1778. Leske, Addit. Klein, p. 110, pl. 49, fig. 8, 9.
1834. Blainville, Actinologie, p. 212.
1842. Desor, Agassiz's Monog. Échin. Galérites, p. 45, pl. 6, fig. 16.

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1855. Gray, Catal. Rec. Echin. Brit. Mus., p. 32.
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1866. Martens, Archiv f. Naturg., **32**, bd. 1, p. 169.

E. semilunaris Gmelin.

1790. Gmelin, Syst. Nat., **1**, pt. 6, p. 3184 (*Echinus*).
1816. Lamarck, Anim. sans Vert., **3**, p. 19.
1819. Blainville, Dict. Sci. Nat., **14**, p. 196.
1835. Agassiz, Mém. Soc. Sci. Nat. Neuchatel, **1**, p. 187.
1836. Milne Edwards, Cuvier's Règne Anim., **10**, p. 27, pl. 14, fig. 1 (*Echinus*).
1837. Des Moulins, Études, p. 340.
1864. Lutken, Bidrag Echin., p. 56.
1869. A. Agassiz, Bull. Mus. Comp. Zoöl., **1**, p. 267.
1872. A. Agassiz, Rev. Echini, p. 118, 333.
1874. Lovén, K. Svenska Veten. Akad. Handl., **11**, no. 7, pl. 9, fig. 83.
1881. Bell, Ann. Mag. Nat. Hist., ser. 5, **8**, p. 437.
1883. Lovén, K. Svenska Veten. Akad. Handl., **19**, no. 7, pl. 11, fig. 116, 117, pl. 12, fig. 132.
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1895. Sluiter, Konin, Zoöl. Genoot. Amsterdam, Bijdr. Dierkunde, aflev. 17–18, p. 73.
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1907. Mortensen, Danish Ingolf-Exped., **4**, pt. 2, p. 185, 186, 193.
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E. gibbosus Lamarck.

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1835. Agassiz, Mém. Soc. Sci. Nat. Neuchatel, **1**, p. 187.
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1842. Desor, Agassiz's Monog. Échin. Galérites, p. 46, pl. 6, fig. 4–6.
1855. Gray, Catal. Rec. Echin. Brit. Mus., p. 32.

E. echinonea. Des Moulins.

1837. Des Moulins, Études, p. 246. (Galérites.)

E. serialis Desor.

1842. Desor, Agassiz's Monog. Échin. Galérites, p. 48, pl. 6, fig. 10–12.

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1862. Dujardin et Hupé, Échin., p. 545.

E. elegans Desor.

1842. Desor, Agassiz's Monog. Échin. Galérites, p. 47, pl. 6, fig. 7–9.

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E. conformis Desor.

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E. cruciatus Agassiz.

1842. Agassiz, Monog. Echin. Galérites, p. 46, pl. 6, fig. 1–3.

1855. Gray, Catal. Rec. Echin. Brit. Mus., p. 33.

E. crassus Agassiz.

1847. Agassiz, Ann. Sci. Nat., ser. 3, **7**, p. 143.

1855. Gray, Catal. Rec. Echin. Brit. Mus., p. 33.

1862. Dujardin et Hupé, Échin., p. 546.

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E. abnormalis Loriol.

1883. Loriol, Mém. Soc. Phys. Genève, **28**, no. 8, p. 41, pl. 5, fig. 2.

MICROPETALON A. Agassiz and H. L. Clark.

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M. PURPUREUM A. Agassiz and H. L. Clark.

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1911. Westergren, Ante, p. 63.

EXPLANATION OF THE PLATES.

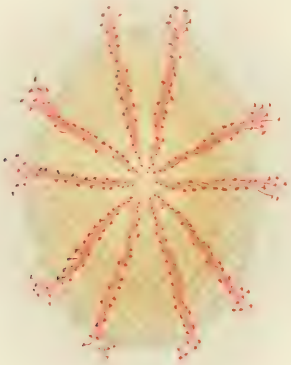
PLATE 1.

PLATE **1**.

1–2. **Echinonëus cyclostomus** Leske.

1.— Seen from the abactinal side. Natural colors. 30 mm. long.
2.— Same in profile, showing the left anterior interambulacrum and the left posterior interambulacrum.

Port Antonio, Jamaica. H. L. Clark.
Twice natural size.



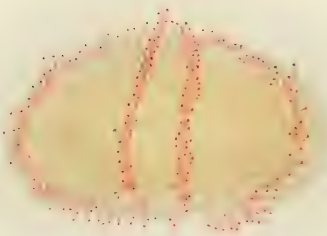


PLATE 2.

PLATE 2.

1–7. **Echinonëus cyclostomus** LESKE.

1.— Actinal side of alcoholic specimen, measuring 30 mm. long. Barbados (?).
2.— The same from the abactinal side.
3.— The same in profile, facing the left anterior and the left posterior interrad.
4.— Abactinal side of alcoholic specimen, measuring 10 mm. long. Makemo Island, Paumotu Islands.
5.— The same from the actinal side.
6.— The same in profile facing the left anterior and the left posterior interrad.
7.— Actinal side of alcoholic specimen, measuring 6 mm. long. Makemo Island.

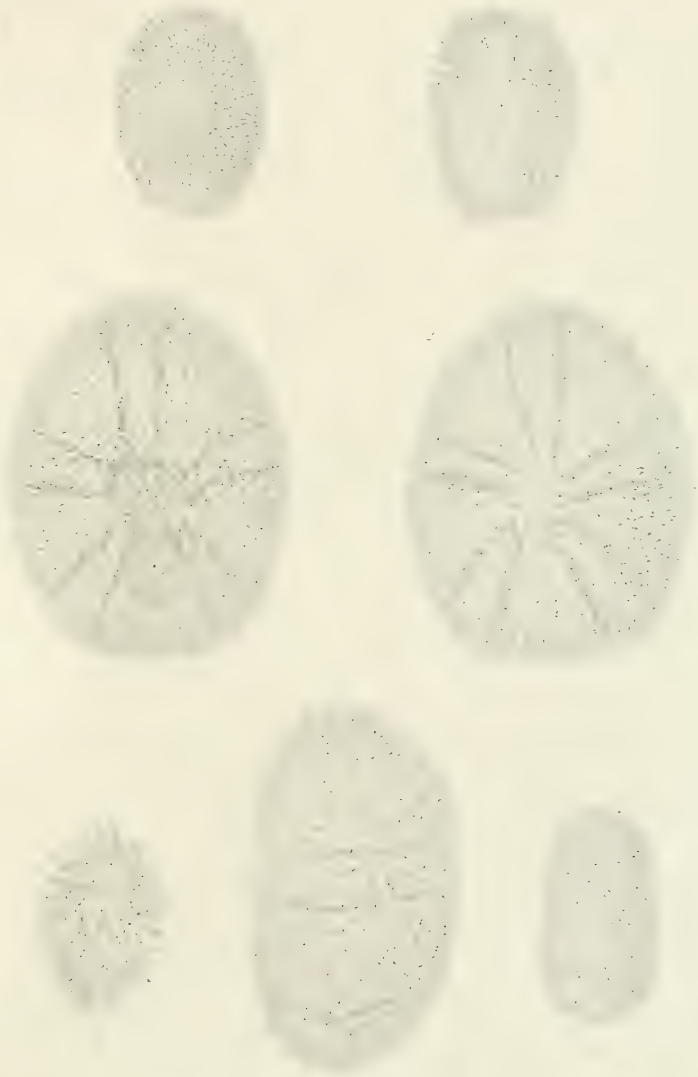


PLATE 3.

PLATE 3.

1–5. **Echinonëus cyclostomus** Leske.

1.— Actinal side of alcoholic specimen measuring 4.40 mm. long. Makemo Island, Paumotu Islands.
2.— The same from the abactinal side.
3.— Actinal side of dry specimen measuring 27 mm. long. Pacific (?).
4.— The same from the abactinal side.
5.— The same in profile facing the left anterior and the left posterior interrad.

PLATE 4.

PLATE 4.

1–25. **Echinonëus cyclostomus** LESKE.

Outlines of test.

1.— Actinal side of specimen measuring 37 mm. long. Mauritius.
2.— Actinal side of specimen measuring 30 mm. long. Mauritius.
3.— Actinal side of specimen measuring 29 mm. long. Bourbon.
4.— The same in profile facing the left anterior and the left posterior interrad.
5.— End view of same, presenting odd anterior ambulacrum.
6.— Actinal side of specimen measuring 27 mm. long. Pacific (?).
7.— Actinal side of specimen measuring 19 mm. long. Pacific (?).
8.— Actinal side of specimen measuring 27 mm. long. Makemo Island, Paumotu Islands.
9.— The same in profile.
10.— End view of same.
11.— Actinal side of specimen measuring 17 mm. long. Bourbon.
12.— Actinal side of specimen measuring 18 mm. long. Kingsmills Island.
13.— The same in profile.
14.— End view of same.
15.— Actinal side of specimen measuring 13 mm. long. Gilbert Islands.
16.— The same in profile.
17.— End view of same.
18.— Actinal side of specimen measuring 14 mm. long. Gilbert Islands.
19.— Actinal side of specimen measuring 7 mm. long. Mujeres Island, Yucatan.
20.— Actinal side of specimen, measuring 19 mm. long. Pacific (?).
21.— The same in profile.
22.— End view of same.
23.— Actinal side of specimen measuring 17 mm. long. Cuba.
24.— The same in profile.
25.— Actinal side of specimen measuring 5.5 mm. long. Mauritius.

All the profile views show the left anterior and the left posterior interrad.
The end views show odd anterior ambulacrum.
The enlargement is about once natural size.
Figures 8–10, are from alcoholic specimens; the other figures are from dry specimens.

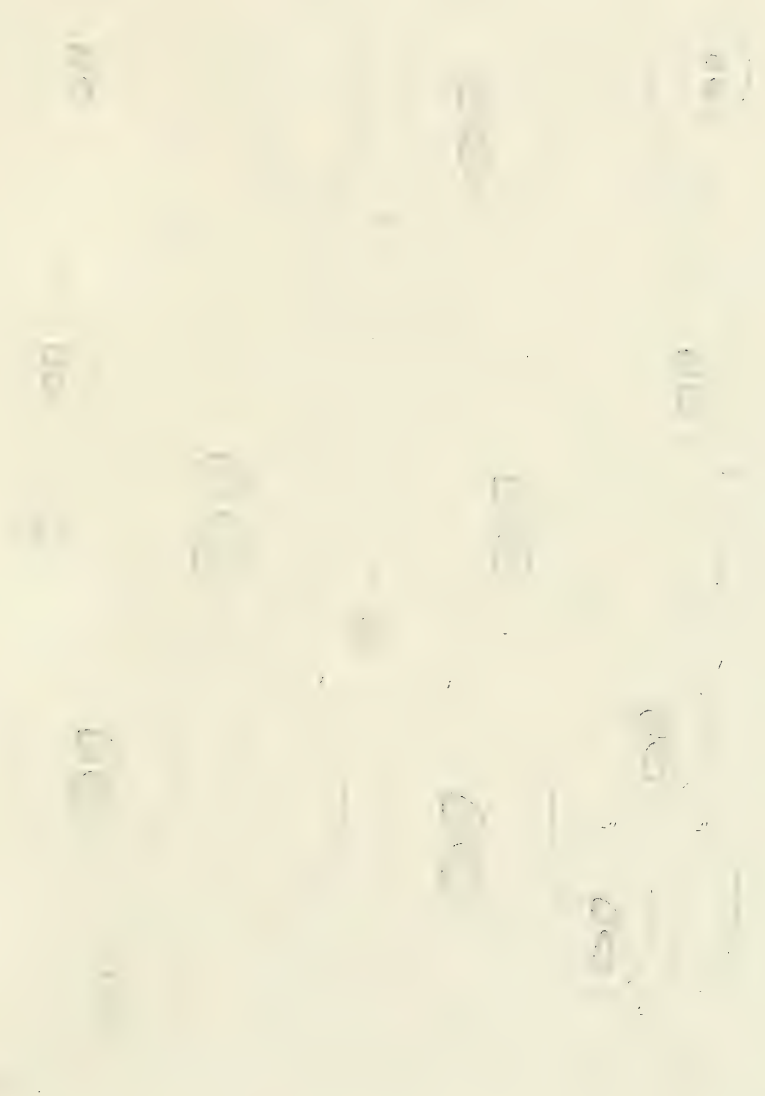


PLATE 4.

1–25. **Echinonëus cyclostomus** Leske.

Outlines of test.

1.— Actinal side of specimen measuring 37 mm. long. Mauritius.
2.— Actinal side of specimen measuring 30 mm. long. Mauritius.
3.— Actinal side of specimen measuring 29 mm. long. Bourbon.
4.— The same in profile facing the left anterior and the left posterior interrad.
5.— End view of same, presenting odd anterior ambulacrum.
6.— Actinal side of specimen measuring 27 mm. long. Pacific (?).
7.— Actinal side of specimen measuring 19 mm. long. Pacific (?).
8.— Actinal side of specimen measuring 27 mm. long. Makemo Island, Paumotu Islands.
9.— The same in profile.
10.— End view of same.
11.— Actinal side of specimen measuring 17 mm. long. Bourbon.
12.— Actinal side of specimen measuring 18 mm. long. Kingsmills Island.
13.— The same in profile.
14.— End view of same.
15.— Actinal side of specimen measuring 13 mm. long. Gilbert Islands.
16.— The same in profile.
17.— End view of same.
18.— Actinal side of specimen measuring 14 mm. long. Gilbert Islands.
19.— Actinal side of specimen measuring 7 mm. long. Mujeres Island, Yucatan.
20.— Actinal side of specimen, measuring 19 mm. long. Pacific (?).
21.— The same in profile.
22.— End view of same.
23.— Actinal side of specimen measuring 17 mm. long. Cuba.
24.— The same in profile.
25.— Actinal side of specimen measuring 5.5 mm. long. Mauritius.

All the profile views show the left anterior and the left posterior interrad.
The end views show odd anterior ambulacrum.
The enlargement is about once natural size.
Figures 8–10, are from alcoholic specimens; the other figures are from dry specimens.

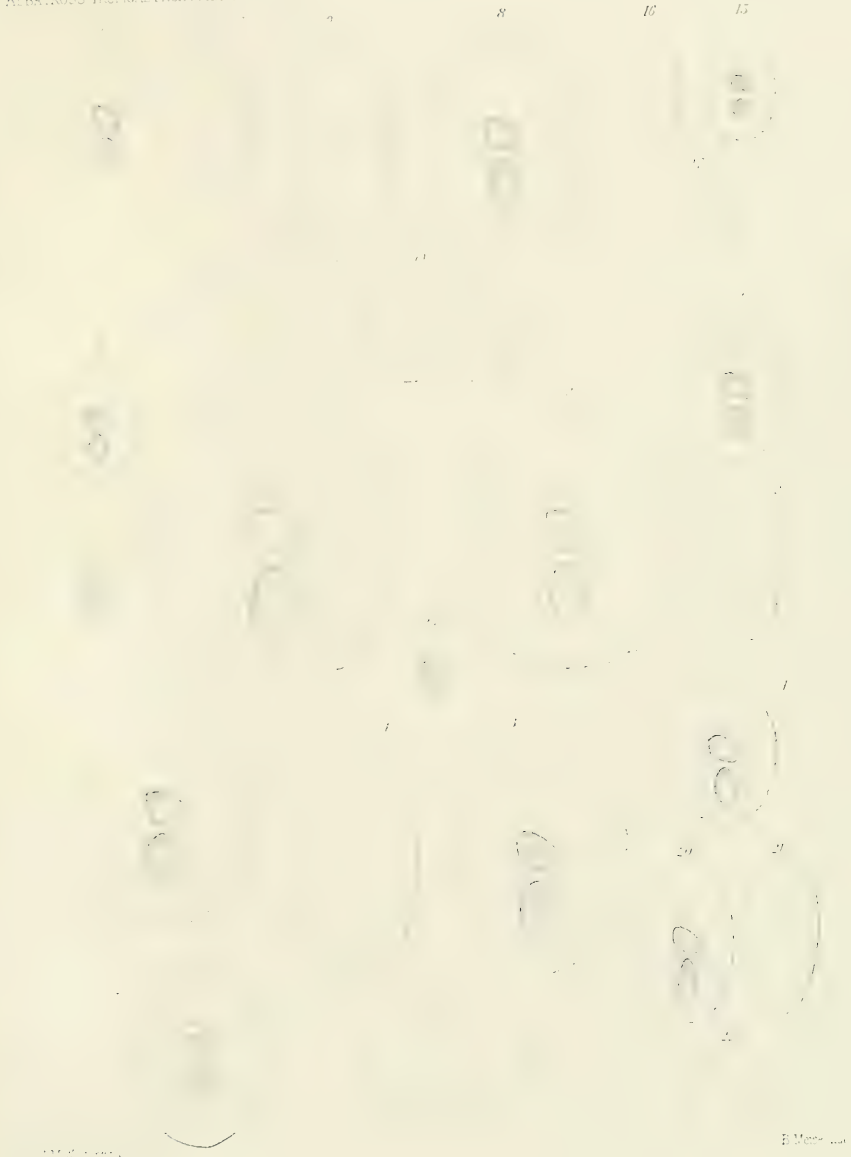


PLATE 5.

PLATE 5.

1–17. **Echinonëus cyclostomus** Leske.

1–10, 12–17. Actinal side of test. 11. Abactinal side of test.

1.— Specimen, including spines, measuring 30 mm. long. Lord Howe Island.
2.— Specimen measuring 34 mm. long. Lord Howe Island.
3.— Specimen measuring 27.5 mm. long. Mauritius.
4.— Specimen measuring 30 mm. long. Mauritius.
5.— Specimen measuring 9 mm. long. Mauritius.
6.— Specimen measuring 27 mm. long. Makemo Island, Paumotu Islands.
7.— Specimen measuring 19 mm. long. Pacific (?).
8.— Specimen measuring 20 mm. long. Pacific (?).
9.— Specimen measuring 23 mm. long. Pacific (?).
10.— Specimen measuring 27 mm. long. Pacific (?).
11.— Abactinal side of a specimen measuring 20 mm. long. Cuba.
12.— Specimen measuring 6 mm. long. Port Antonio, Jamaica.
13.— Specimen measuring 9 mm. long. Jamaica.
14.— Specimen measuring 10 mm. long. Jamaica.
15.— Specimen measuring 16 mm. long. Jamaica.
16.— Specimen measuring 22 mm. long. Jamaica.
17.— Specimen measuring 16 mm. long. Florida.

All the figures are enlarged once the natural size.
Figures 1, 2, 4, 5, 7–11 are from dry specimens; the other figures are from alcoholic specimens.

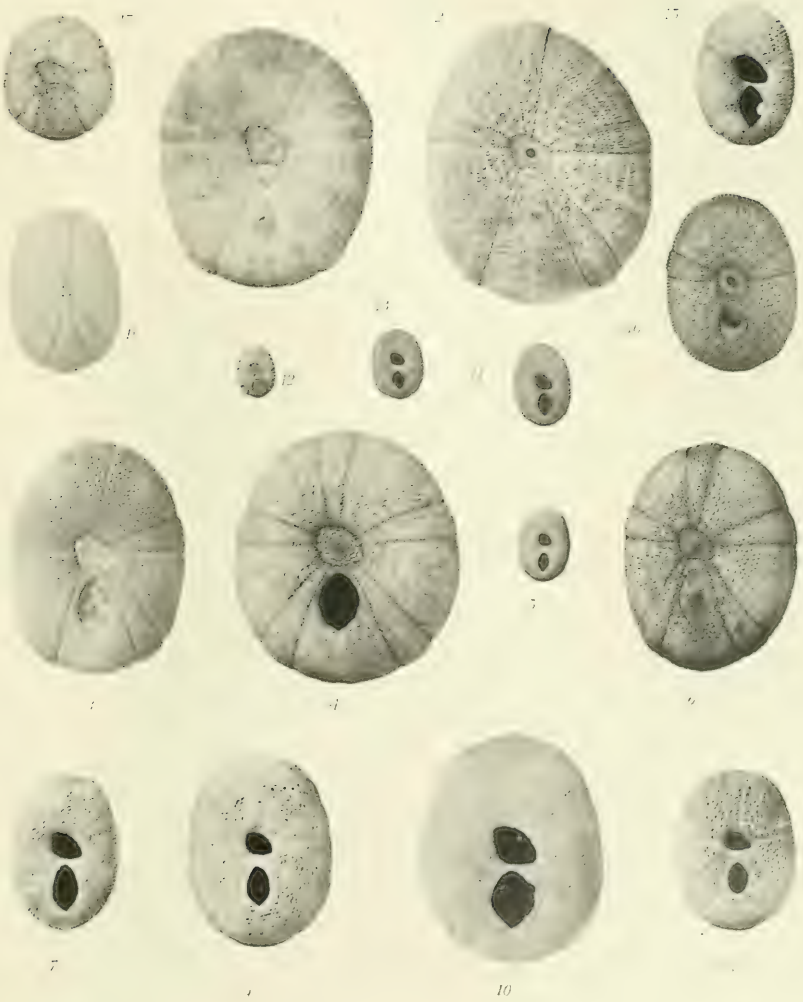


PLATE 6.

PLATE 6.

1–8. **Echinonëus cyclostomus** Leske.

1.— Development of the coronal plates, seen from interior of an alcoholic specimen without spines, measuring 5.90 mm. long. Jamaica.
2.— Bivium and odd posterior interambulacrum, seen from interior of a specimen measuring 4.19 mm. long. Jamaica.
3.— The same, from a specimen measuring 6 mm. long. Jamaica.
4.— The same from a specimen measuring 14 mm. long. Jamaica.
5.— The same from a specimen measuring 22 mm. long. Jamaica.
6.— The same from a specimen measuring 25 mm. long. Jamaica.
7.— Bivium and odd posterior interambulacrum, seen from interior of a specimen measuring 4.40 mm. long. Makemo Island, Paumotu Islands.
8.— The same from a specimen measuring 27 mm. long. Makemo Island.

The magnification of Figures 4–6, and 8 is the same; that of Figures 2, 3, and 7 is on a slightly larger scale.

PLATE 7.

PLATE 7.

Echinonëus cyclostomus LESKE.

Arrangement of the coronal plates, seen from inside of a dry specimen measuring 37 mm. long. Mauritius.

PLATE 8.

PLATE 8.

1–5. **Echinonëus cyclostomus** Leske.

1.— Intestine in place, seen from below. Specimen measuring 26 mm. long.
2.— Reproductive organs and alimentary canal, seen from above, free of its test, which measured 23 mm. long.
3.— Alimentary canal, from actinal side.
4.— Abactinal loop of the alimentary canal. Reproductive organs removed.
5.— Alimentary canal, actinal side. Intestinal appendage and part of actinal loop turned to show the curve of abactinal loop to the anal system.

The same specimen was used for figures 2–5.
Port Antonio, Jamaica, H. L. Clark.

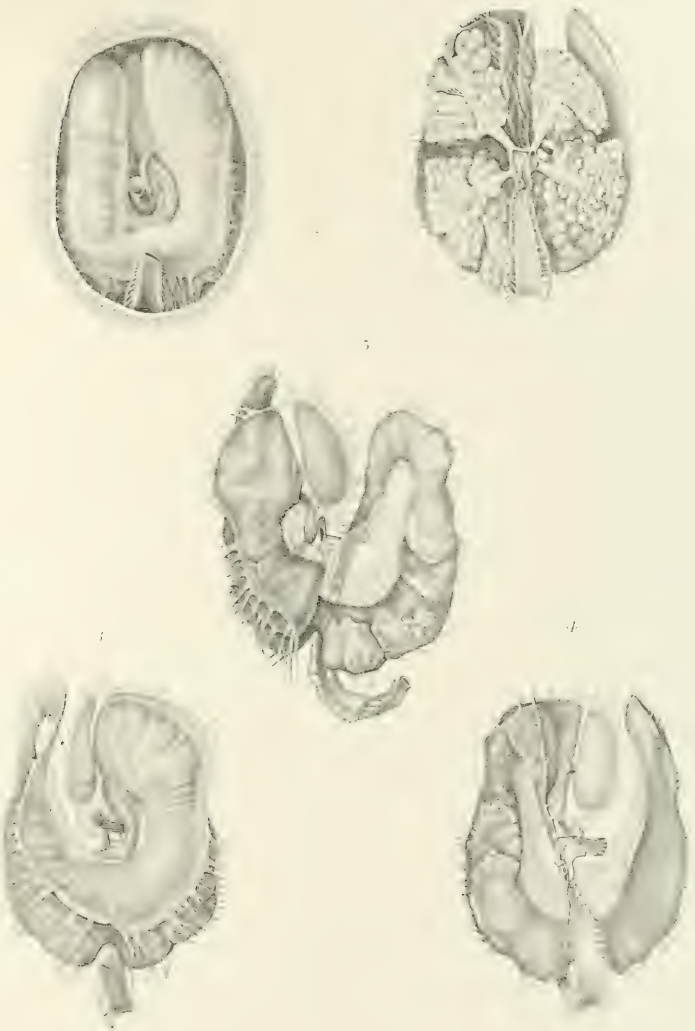


PLATE 9.

PLATE 9.

1–6. **Echinonëus cyclostomus** Leske.

1.— Anterior part of actinal loop of the alimentary canal with mesentery, showing the actinal intestinal appendage, oesophagus, madreporic tube, and termination of the genital ducts. Test with spines measuring 23 mm. long.
2.— The same as above, seen from abactinal side.
3.— Intestinal appendage with intestine cut, exposing insertion of its neck. Same specimen as Figures 1–2.
4.— Intestine in place, seen from below. Test without spines measuring 5 mm. long.
5.— The same seen from below free from the test.
6.— The same seen from above.

go. generative organ.
ia. actinal intestinal appendage.
m. madreporic tube.
oes. oesophagus.

Port Antonio, Jamaica, H. L. Clark.

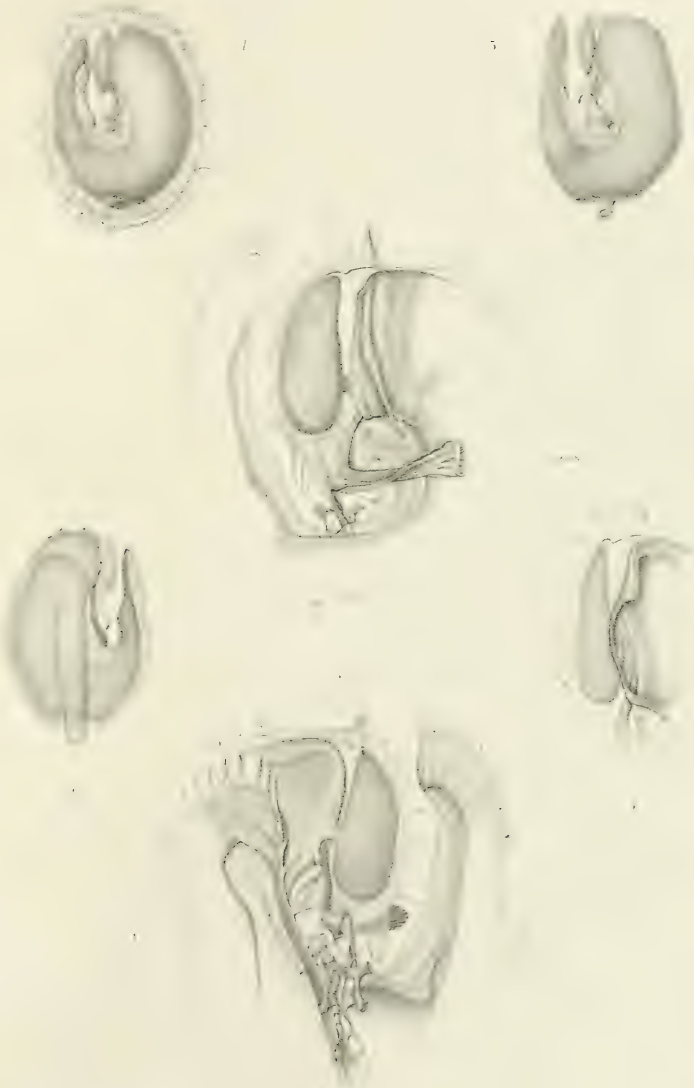


PLATE 10.

PLATE 10.

1–10. **Echinonëus cyclostomus** Leske.

1.— Alimentary canal, madreporic tube, and reproductive organs, seen from right side, with both sides of test removed. Specimen with spines measured 22 mm. long.

2.— The same seen from left side.

3.— Actinal part of intestine, actinal intestinal appendage, oesophagus, and madreporic tube removed from test, which without spines measured 4.19 mm. long.

4.— Longitudinal section of anterior end of test, showing appendage of alimentary canal, oesophagus, and madreporic tube, held in place by mesenteries. Test with spines measured 22 mm. long.

5.— Profile of oesophagus, madreporic tube, and genital ducts, showing folding of edge of mesentery. Specimen with spines measured 21 mm. long.

6.— Axial organ with mesentery laid back, showing nerve along outside edge. Same individual as Figure 5.

7.— Oral system with surrounding coronal plates, seen from interior, with pentagonal and radial nerves, and water-vascular canals, showing oesophagus fastened to inner margin of pentagon. Dissected to show mouth in centre of buccal membrane. Test without spines measured 21 mm. long.

8.— Nerve with radial canal, and two ampullae, from odd anterior ambulacrum, actinal side, midway actinal system, and ambitus. Test without spines measuring 21 mm. long.

9.— Mesentery and outside edge of intestine, showing surface folds. Test without spines measuring 21 mm. long.

10.— Outside edge of abactinal alimentary canal with mesentery. Test with spines measuring 22 mm. long.

Port Antonio, Jamaica, H. L. Clark.

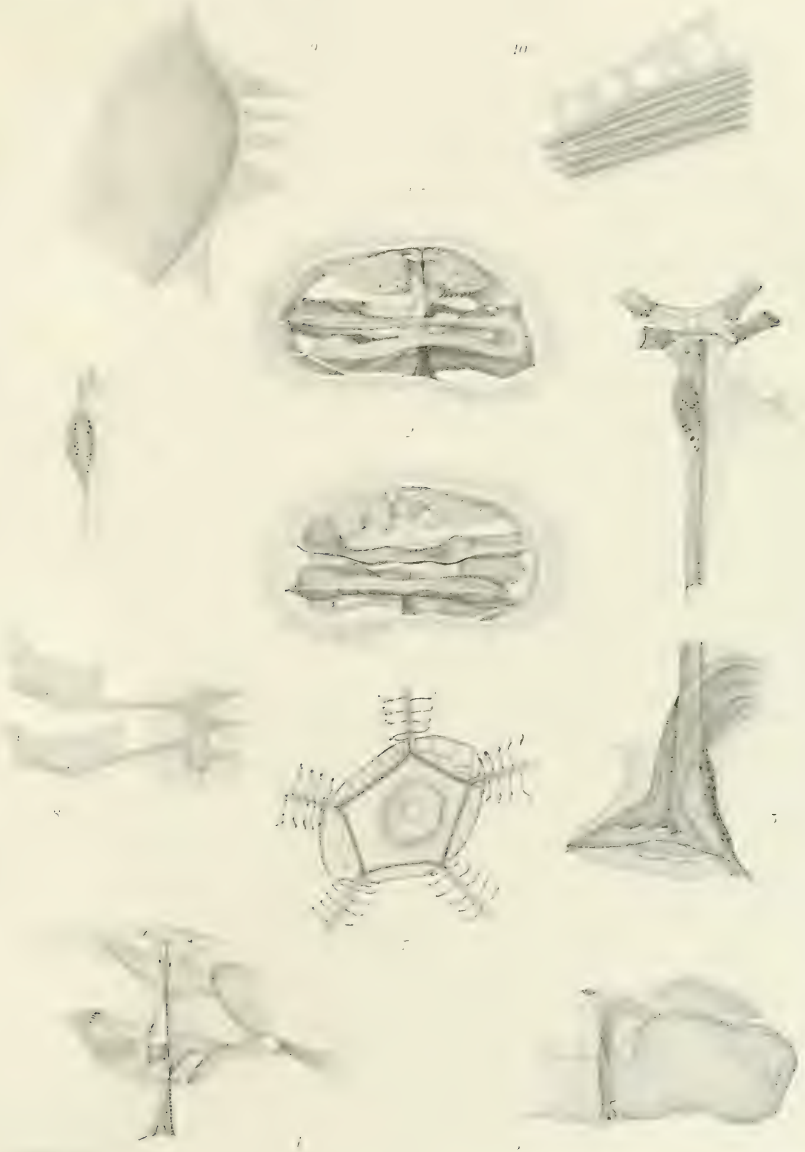


PLATE 11.

PLATE **11**.

1–10. **Echinonëus cyclostomus** Leske.

1.— Transverse section, showing actinal floor and lantern in position. Test without spines measuring 3.70 mm. long.

2.— Lantern in natural position, from same specimen as Figure 1, showing oesophagus, compasses, and various muscles. Diameter of actinostome 1.35 mm. and of lantern 1.24 mm. long.

3.— Oral and part of anal system, showing gills, tentacles, and sphaeridia. Test without spines measuring 4.19 mm. long.

4.— First spicules round the teeth on the buccal membrane, seen from interior. Same specimen as Figures 1, 2, and 3.

5.— Interior view of actinal system with the rudimentary auricles. Diameter of actinostome 1.26 mm. Specimen without spines measuring 4.19 mm. long.

6.— Odd anterior ambulacrum, interior view with auricles, enlargement of same specimen as Figure 5.

7.— Centre of oral system expanded, showing tips of teeth. Test without spines measuring 4.10 mm. long.

8.— Profile longitudinal section exposing lantern, madreporic tube, and right side of alimentary canal. Test without spines measuring 4.25 mm. long.

9.— Profile longitudinal section, lantern resorbed, with view of oesophagus and right side of alimentary canal. Test without spines measuring 5.16 mm. long.

10.— Actinostome interior view, auricles resorbed, length of mouth aperture 1.18 mm. Same specimen as Figure 9.

Port Antonio, Jamaica, H. L. Clark.

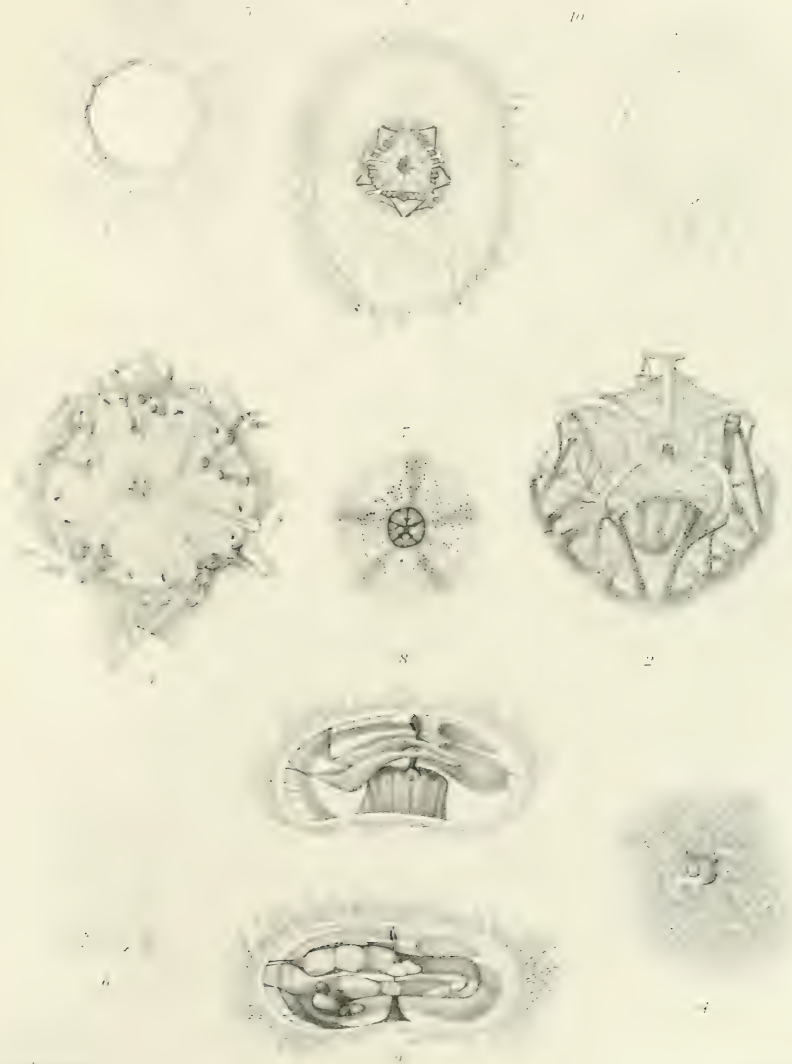


PLATE 12.

PLATE 12.

1–12. **Echinonëus cyclostomus** Leske.

1.— Lantern seen from above, measuring 1.30 mm. in diameter.
2.— The same seen from below.
3.— The same in profile, height 0.75 mm.
4.— Pyramid and tooth, seen from exterior, length 0.85 mm.
5.— The same seen from interior.
6.— Half of same pyramid, without tooth, seen from exterior.
7.— The same seen from interior.
8.— Pyramid with tooth, same as Figure 4, seen from above.
9.— Grooved tooth, *b*. seen in profile, *c*. dorsal view, length 0.62 mm.
10.— The brace; *a*. seen from above with epiphysis on one side, *b*. the same from below, *c*. profile, length 0.44 mm.
11.— Compass; *a*. seen from above, *b*. the same in profile, length 0.62 mm. long.
12.— Epiphysis; *a*. exterior view, *b*. interior view, length 0.44 mm.

All the figures are from a specimen without spines measuring 4.19 mm.
Port Antonio, Jamaica, H. L. Clark.

7
8
6
1
2
12
b
a
9
a
b
c
b
a

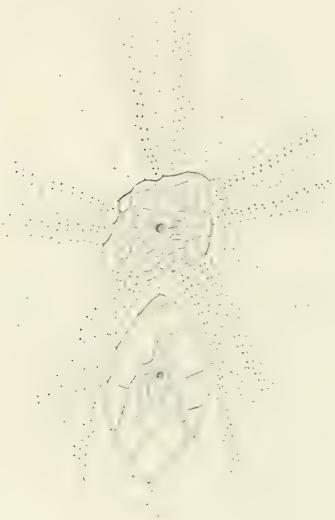
PLATE 13.

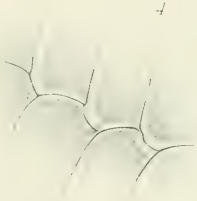
PLATE 13.

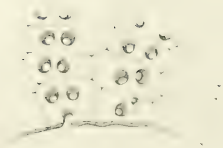
1–6. **Echinonëus cyclostomus** Leske.

1.— Interior view of actinal side, from alcoholic specimen, measuring 4.40 mm. long. Makemo Island, Paumotu Islands.
2.— Actinal side seen from interior. Test measuring 27 mm. long. Makemo Island.
3.— Odd anterior ambulacrum with part of the right and left anterior interradial plates, at edge of actinal system, seen from interior.
4.— Interior view of median interambulacral suture in right posterior interambulacrum, near actinostome, showing overlapping of plates.
5.— Odd anterior ambulacrum, near ambitus, actinal side, seen from interior.
6.— Ocular and abactinal ambulacral plates of odd anterior ambulacrum, interior view.

Figures 3–6 from a dry specimen, measuring 37 mm. long. Mauritius.
The enlargement is identical in Figures 3, 5, 6.







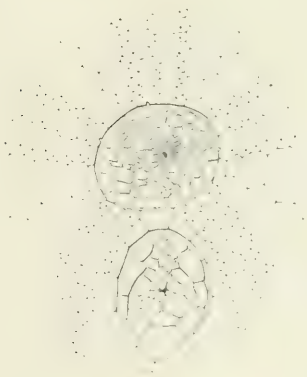


PLATE 14.

PLATE **14.**

1–7. **Echinonëus cyclostomus** Leske.

Abactinal system.

1.— Exterior view. Alcoholic specimen denuded of its spines measuring 4.40 mm. long. Makemo Island, Paumotu Islands.
2.— The same, interior view.
3.— Interior view. Alcoholic specimen, test without spines measuring 4.19 mm. long. Port Antonio, Jamaica.
4.— Interior view. Alcoholic specimen measuring 12.5 mm. long. Jamaica.
5.— Exterior view. Dry specimen, without spines measuring 26 mm. long. Pacific (?).
6.— Exterior view. Dry specimen, without spines measuring 27 mm. long. Pacific (?).
7.— Interior view. Alcoholic specimen measuring 27 mm. long. Makemo Island.

The enlargement of Figures 5–7, is the same, the others are not identical.

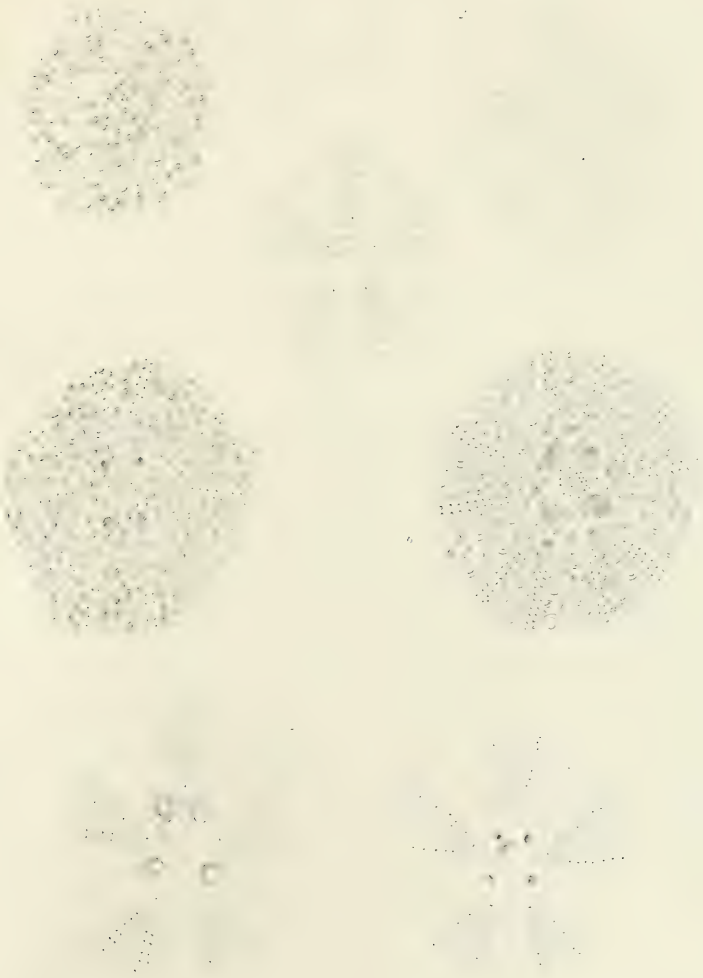


PLATE 15.

PLATE 15.

1–12. **Echinonëus cyclostomus** Leske.

Oral and anal systems.

1.— Alcoholic specimen from Makemo Island, Paumotu Islands, measuring 4.40 mm. long.
2.— Alcoholic specimen from Makemo Island, measuring 27 mm. long.
3.— Dry specimen from Lord Howe Island, measuring 30 mm. long.
4.— Dry specimen from Lord Howe Island, measuring 34 mm. long.
5.— Dry specimen from Mauritius, measuring 27 mm. long.
6.— Alcoholic specimen from Mauritius, measuring 27.5 mm. long.
7.— Anal system of dry specimen from Bourbon, measuring 29 mm. long.
8.— Oral and anal system of alcoholic specimen from Port Antonio, Jamaica, measuring 6 mm. long.
9.— Anal system of alcoholic specimen from Jamaica, measuring 10 mm. long.
10.— Oral and anal system of alcoholic specimen from Jamaica, measuring 24 mm. long.
11.— Anal system of alcoholic specimen from Florida, measuring 16 mm. long.
12.— Anal system of alcoholic specimen from Barbados (?) 26 mm. long.

In all the figures the distance between the two apertures, is in natural proportion.

Figure 1 is larger proportionately. Figures 8, 9, are of the same magnification. The others are magnified equally excepting figures 3–4 which are slightly larger.

PLATE 16.

PLATE **16.**

1–14. **Echinonëus cyclostomus** Leske.

Sphaeridia.

1–4.— Alcoholic specimen, test measuring 12 mm. long, from Fakarava Island, Paumotu Islands.
1.— From right anterior ambulacrum, height 0.13 mm.
2.— From odd anterior ambulacrum, height 0.13 mm.
3.— From left anterior ambulacrum, height 0.12 mm.
4.— From left posterior ambulacrum, height 0.13 mm.
5–7.— Dry specimen, test measuring 34 mm., 8, test measuring 30 mm. long, from Lord Howe Island.
5.— Both from odd anterior ambulacrum, height 0.16 mm.
6.— From left anterior ambulacrum, height 0.10 mm.
7.— From left posterior ambulacrum, height 0.16 mm.
8.— Both from right anterior ambulacrum, height 0.18 mm.
9–14.— Alcoholic specimen, test measuring 18 mm., 13–14, test measuring 10 mm. long, from Makemo Island, Paumotu Islands.
9.— From right posterior ambulacrum, height 0.13 mm.
10.— From right anterior ambulacrum, height 0.14 mm.
11.— From odd anterior ambulacrum, height 0.15 mm.
12.— Both from left posterior ambulacrum, height 0.13 mm., 0.14 mm.
13.— Both from right posterior ambulacrum, height 0.10 mm.
14.— From left anterior ambulacrum, height 0.9 mm.

All equally magnified.

PLATE 17.

PLATE **17**.

1–9. **Echinonëus cyclostomus** Leske.

Sphaeridia.

1–6.— Alcoholic specimen, test measuring 30 mm., 6, test measuring 26 mm. long. Barbados (?).

1.— Both from right posterior ambulacrum, height 0.22 mm., 0.20 mm.
2.— From right anterior ambulacrum, height 0.19 mm.
3.— Both from odd anterior ambulacrum, height 0.20 mm., 0.19 mm.
4.— Both from left anterior ambulacrum, height 0.17 mm., 0.19 mm.
5.— From left posterior ambulacrum, height 0.19 mm.
6.— Both from right anterior ambulacrum, height 0.20 mm.

7–9.— Alcoholic specimen measuring 23 mm. long. Fakarava Island, Paumotu Islands.

7.— Both from right posterior ambulacrum, height 0.13 mm., 0.12 mm.
8.— From odd anterior ambulacrum, height 0.14 mm.
9.— Both from left posterior ambulacrum, height 0.14 mm., 0.12 mm.

Figures 1–6 the magnification is slightly reduced, the others the same as those of Plate 16.

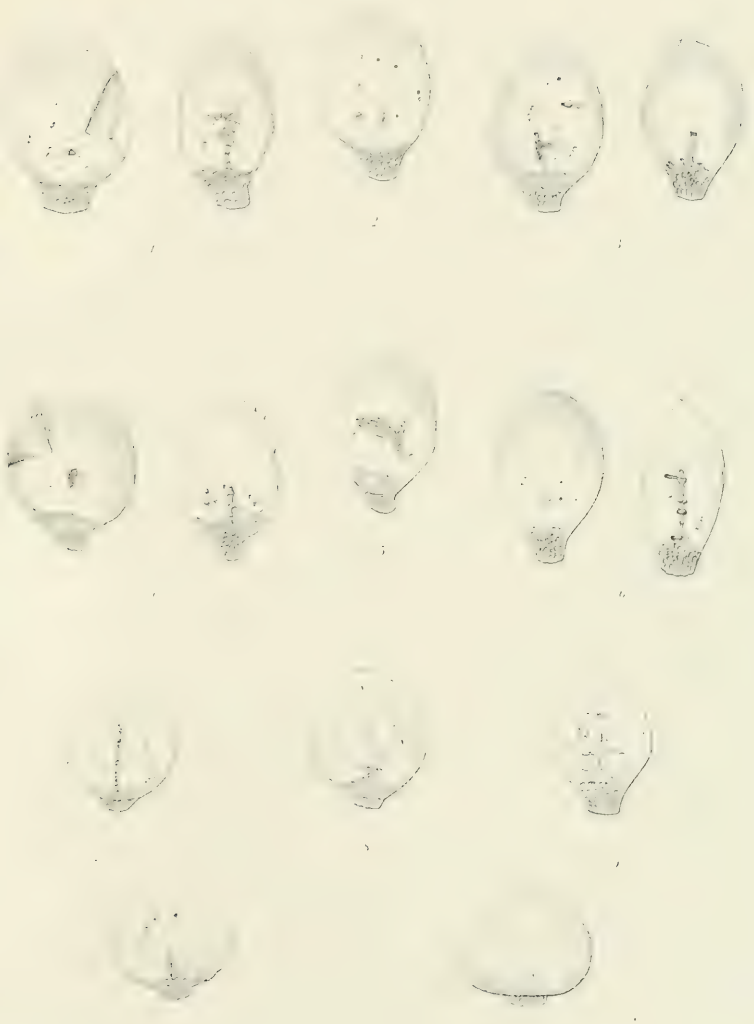


PLATE 18.

PLATE 18.

1–11. **Echinonëus cyclostomus** Leske.

Valves of tridentate pedicellariae.

1.— Stalk and head, 0.95 mm. long.
2.— Valve A, 0.51 mm. interior view.
3.— Valve B, 0.50 mm. interior view.
4.— Valve B, 0.50 mm. interior view, profile.
5.— Valve C, 0.47 mm. interior view.
6.— Valve C, 0.47 mm. exterior view.

Of a single pedicellaria.

1–6.— Are from right anterior interambulacrum, midway between the actinal system and the ambitus. Dry specimen, with spines measuring 34 mm. long. Lord Howe Island.

7.— Valve B, 0.47 mm. interior view, near the actinostome in odd posterior interambulacrum.
8.— Valve B, 0.47 mm. exterior view near the actinostome in odd anterior ambulacrum.
9.— Valve B, 0.45 mm. exterior view midway between actinal system and the ambitus, in right anterior interambulacrum.

7–9.— Alcoholic specimen with spines measuring 15 mm. long. Makemo Island, Paumotu Islands.

10.— Valve C, 0.22 mm. exterior view.
11.— Valve C, 0.22 mm. interior view towards ambitus, actinal side, in left posterior interambulacrum. Test measuring 34 mm. long. Lord Howe Island.

The measurement refers to height of valves natural size.
All of the same enlargement with exception of Figure 1, which is on a smaller scale.

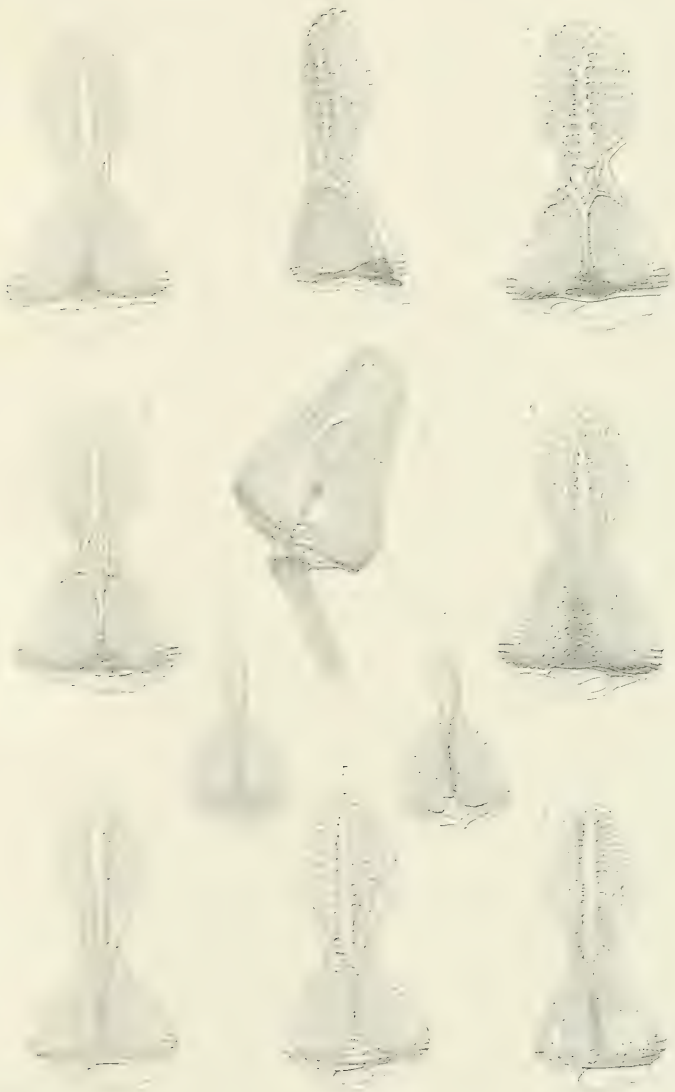


PLATE 19.

PLATE 19.

1–7. **Echinonëus cyclostomus** LESKE.

Valves of tridentate pedicellariae.

1.— Stalk and head, valve B in the centre. Height of head 0.63 mm.
2.— Valve A, 0.63 mm. interior view, profile.
3.— Valve B, 0.62 mm. interior view.
4.— Valve C, 0.61 mm. exterior view.

} Of a single pedicellaria.

1–4 are taken from right posterior interambulacrum, near the actinostome. Alcoholic specimen, measuring 19 mm. long. Fakarava Island, Paumotu Islands.

5.— Valve B, 0.67 mm. interior view.
6.— Valve C, fragment, exterior view, both from odd posterior interambulacrum, towards aboral end of anal system. Alcoholic specimen, measuring 23 mm. long. Fakarava Island.
7.— Valve B, 0.54 mm. interior view, from adoral end of anal system. Alcoholic specimen with spines, measuring 26 mm. long. Barbados (?).

Magnification precisely as on Plate 18.

PLATE 20.

PLATE 20.

1–13. **Echinonëus cyclostomus** Leske.

Valves of tridentate pedicellariae.

1.— Stalk and head, 0.65 mm. from aboral end of anal system. Specimen measuring 12 mm. long.
2.— Valve A, 0.30 mm. interior view.
3.— Valve B, 0.29 mm. exterior view.
4.— Valve C, 0.26 mm. interior view profile, from aboral end of anal system. Test measuring 11 mm. long.

Of a single pedicellaria.

5.— Valve B, 0.32 mm. exterior view, midway between actinostome and ambitus, in right anterior interambulacrum. Test measuring 13 mm. long.
6.— Valve B, 0.44 mm. exterior view, near actinostome, in right anterior interambulacrum. Test measuring 13 mm. long.
7.— Valve B, 0.40 mm. exterior view, adoral end of anal system. Test measuring 13 mm. long.
8.— Valve B, 0.33 mm. exterior view, aboral end of anal system. Test measuring 10 mm. long.
9.— Valve B, 0.38 mm. exterior view, midway between actinostome and ambitus, in odd anterior ambulacrum. Test measuring 12 mm. long.
10.— Valve B, 0.35 mm. exterior view, midway between actinostome and ambitus, in right posterior interambulacrum. Test measuring 10 mm. long.
11.— Valve C, 0.34 mm. exterior view, near actinostome, in left anterior interambulacrum. Test measuring 11 mm. long.
12.— Valve B, 0.39 mm. exterior view, aboral end of anal system. Test measuring 18 mm. long.
13.— Valve C, 0.32 mm. exterior view, adoral end of anal system. Test measuring 18 mm. long.

Figures 1–7, and 9 are from specimens from Fakarava Island, Paumotu Islands, Figures 8, 10–13 are from specimens from Makemo Island, Paumotu Islands.

All the specimens were alcoholic.

Magnification as on Plate 19.

PLATE 21.

PLATE 21.

1–20. **Echinonëus cyclostomus** Leske.

Valves of ophicephalous pedicellariae.

1.— Stalk and head, 0.63 mm. long, from left posterior interambulacrum, actinal side of ambitus.
2.— Pedicellaria, 0.26 mm. valve C in centre, from right posterior interambulacrum.
3.— Valve A, 0.25 mm. exterior view.
4.— Valve B, 0.23 mm. interior view.
5.— Valve B, 0.23 mm. interior view profile.
6.— Valve C, 0.22 mm. exterior view, from left posterior interambulacrum, actinal side of ambitus.
} Of a single pedicellaria.
7.— Valve C, 0.25 mm. exterior view.
8.— Valve A, 0.28 mm. exterior view, from right posterior interambulacrum, actinal side of ambitus.
} Same pedicellaria.

Figures 1–8. Dry specimen with spines measuring 34 mm. long. Lord Howe Island.

9.— Valve B, 0.21 mm. interior view.
10.— Valve C, 0.20 mm. exterior view, from left posterior interambulacrum towards apical system. Test with spines measuring 30 mm. long. Lord Howe Island.
} Same pedicellaria.
11.— Valve B, 0.16 mm. interior view.
12.— Valve C, 0.15 mm. interior view, from left anterior interambulacrum, apical system. Alcoholic specimen measuring 11 mm. long. Fakarava Island, Paumotu Islands.
} Same pedicellaria.
13.— Valve B, 0.21 mm. interior view, from left anterior interambulacrum, midway between actinostome and ambitus. Alcoholic specimen, with spines measuring 15 mm. long. Makemo Island, Paumotu Islands.
14.— Valve C, 0.19 mm. exterior view, from right anterior interambulacrum, actinal side of ambitus. Test measuring 15 mm. long. Makemo Island.
15.— Valve A, 0.32 mm. interior view.
16.— Valve B, 0.31 mm. interior view.
17.— Valve C, 0.28 mm. exterior view, from right posterior ambulacrum, towards margin of anal plastron. Alcoholic specimen, with spines measuring 30 mm. long. Barbados (?)
} Of a single pedicellaria.
18.— Valve B, 0.24 mm. interior view from right posterior interambulacrum near apical system. Test measuring 30 mm. long. Barbados (?)
19.— Valve C, 0.22 mm. exterior view, from left posterior interambulacrum. Alcoholic specimen measuring 26 mm. long. Barbados (?)
20.— Valve C, 0.19 mm. exterior view, from left posterior interambulacrum, near apical system. Test measuring 26 mm. long. Barbados (?)

The enlargement of Figures 2 to 20 is the same, but is on a slightly larger scale than those of Plates 18–20.

PLATE 22.

PLATE 22.

1–26. **Echinonëus cyclostomus** Leske.

1–16. Valves of globiferous pedicellariae.

1.— Stalk and head, 0.74 mm. long, from left anterior ambulacrum, one third way between actinal system and ambitus.

2.— Pedicellaria, 0.36 mm. valve C in centre, from right posterior interambulacrum, midway between actinal system and ambitus.

3.— Valve A, 0.38 mm. interior view.
4.— Valve B, 0.37 mm. interior view.
5.— Valve B, 0.37 mm. interior view, profile.
6.— Valve C, 0.36 mm. interior view.
7.— Valve C, 0.36 mm. exterior view.
} Of a single pedicellaria, same as Figure 1.

8.— Valve A, 0.26 mm. exterior view.
9.— Valve C, 0.26 mm. interior view, from right posterior interambulacrum, ambitus.
} Same pedicellaria.

10.— Valve B, 0.34 mm. interior view.
11.— Valve C, 0.32 mm. exterior view, from right posterior interambulacrum, toward apical system.
} Same pedicellaria.

12.— Valve B, 0.32 mm. interior view, from right posterior interambulacrum, near genital plate.

1–12. Dry specimen with spines 34 mm. long. Lord Howe Island.

13.— Valve A, 0.28 mm. interior view, profile.
14.— Valve B, 0.27 mm. interior view, from right posterior interambulacrum. Alcoholic specimen measuring 19 mm. long. Fakarava Island, Paumotu Islands.
} Same pedicellaria.

15.— Valve B, 0.31 mm. interior view.
16.— Valve C, 0.30 mm. interior view, from right posterior interambulacrum, near apical system. Alcoholic specimen, with spines measuring 30 mm. long. Barbados (?).
} Same pedicellaria.

17–26. Valves of tridentate pedicellariae.

17.— Head and stalk, 0.51 mm. from left anterior interambulacrum, one third way between actinostome and ambitus. Dry specimen, with spines measuring 30 mm. long. Lord Howe Island.

18.— Valve B, 0.17 mm. interior view.
19.— Valve B, 0.17 mm. interior view, profile.
} Same valve. Same specimen as Figure 17.

20.— Valve C?, 0.17 mm. interior view.
21.— Valve C?, 0.17 mm. exterior view from anal system, near the interambulacrum. Dry specimen, with spines measuring 34 mm. long. Lord Howe Island.
} Same valve.

22.— Valve B, 0.15 mm. interior view, from anal system. Alcoholic specimen, measuring 10 mm. long. Makemo Island, Paumotu Islands.

23.— Valve A, 0.17 mm. interior view, from adoral end of anal system. Alcoholic specimen, measuring 18 mm. long. Makemo Island.

24.— Valve C, 0.31 mm. exterior view, from adoral end of anal system.
25.— Valve C, 0.23 mm. exterior view, from aboral end of anal system.
26.— Valve A, 0.31 mm. interior view, from aboral end of anal system.

24–26. Alcoholic specimen, with spines measuring 26 mm. long. Barbados (?).

The enlargement of Figures 2 to 16 is the same as Plate 18. Figures 18 to 26 are on a slightly larger, but not identical scale; Figures 1–17 are smaller.

PLATE 23.

PLATE 23.

1–17. **Echinonëus cyclostomus** LESKE.

Valves of pedicellariae.

1.— Valve B, 0.12 mm. interior view. Tridentate pedicellaria, from anal system. Test with spines measuring 4 mm. long.

2.— Valve B, 0.13 mm. interior view. Tridentate pedicellaria, from right posterior ambulacrum, near actinostome. Test with spines measuring 4 mm. long.

3.— Valve A, 0.14 mm. exterior view.
4.— Valve B, 0.13 mm. interior view.
} Ophicephalous pedicellaria, from odd posterior interambulacrum, near margin of anal system. Test with spines measuring 4 mm. long.

5.— Valve B, 0.19 mm. interior view. Globiferous pedicellaria, from left posterior interambulacrum, at ambitus. Test with spines measuring 4 mm. long.

6.— Valve B, 0.20 mm. interior view. Globiferous pedicellaria, from right anterior interambulacrum, at ambitus. Test with spines measuring 5 mm. long.

7.— Valve A, 0.22 mm. exterior view.
8.— Valve B, 0.22 mm. interior view.
} Globiferous pedicellaria, from right anterior interambulacrum, midway between actinostome and ambitus. Test with spines measuring 5 mm. long.

9.— Valve B, 0.28 mm. interior view. Tridentate pedicellaria, from aboral end of anal system. Test measuring 11 mm. long.

10.— Valve B, 0.37 mm. interior view. Tridentate pedicellaria, from aboral end of anal system. Test measuring 20 mm. long.

11.— Valve B, 0.43 mm. interior view. Tridentate pedicellaria, from right anterior interambulacrum, near actinostome. Test measuring 20 mm. long.

12.— Valve B, 0.47 mm. interior view. Tridentate pedicellaria, from odd posterior interambulacrum, near ambitus, actinal side. Test with spines measuring 25 mm. long.

13.— Valve B, 0.47 mm. interior view. Tridentate pedicellaria, from aboral end of anal system. Test with spines measuring 25 mm. long.

14.— Valve B, 0.49 mm. interior view. Tridentate pedicellaria, from adoral end of anal system. Test with spines measuring 26 mm. long.

15.— Valve B, 0.43 mm. interior view. Tridentate pedicellaria, from left posterior interambulacrum, near actinostome. Test measuring 28 mm. long.

16.— Stalk and head of a triphyllous pedicellaria, 0.29 mm. long, from right anterior interambulacrum, near actinostome. Test measuring 11 mm. long.

17.— Valve of triphyllous pedicellaria, 0.04 mm. exterior view, from left anterior interambulacrum, near actinostome. Test measuring 11 mm. long.

Port Antonio, Jamaica. 1909.

Each order of pedicellaria is magnified almost identically except Figures 1 and 2, which are on a larger scale.

A.M. delineavit &c.

PLATE 24.

PLATE 24.

1–7. **Echinonëus cyclostomus** LESKE.

Odd anterior ambulacrum.

1.— From test 6 mm. long,
2.— From test 8 mm. long,
3.— From test 9.5 mm. long,
4.— From test 11 mm. long,
5.— From test 16 mm. long,
6.— From test 18 mm. long,
} Port Antonio, Jamaica.

7.— From test 27 mm. long, Pacific (?).

Increase of the primary tubercles is indicated by numbers and letters.
Figures 6–7 are reduced in magnification, the others in relative size.

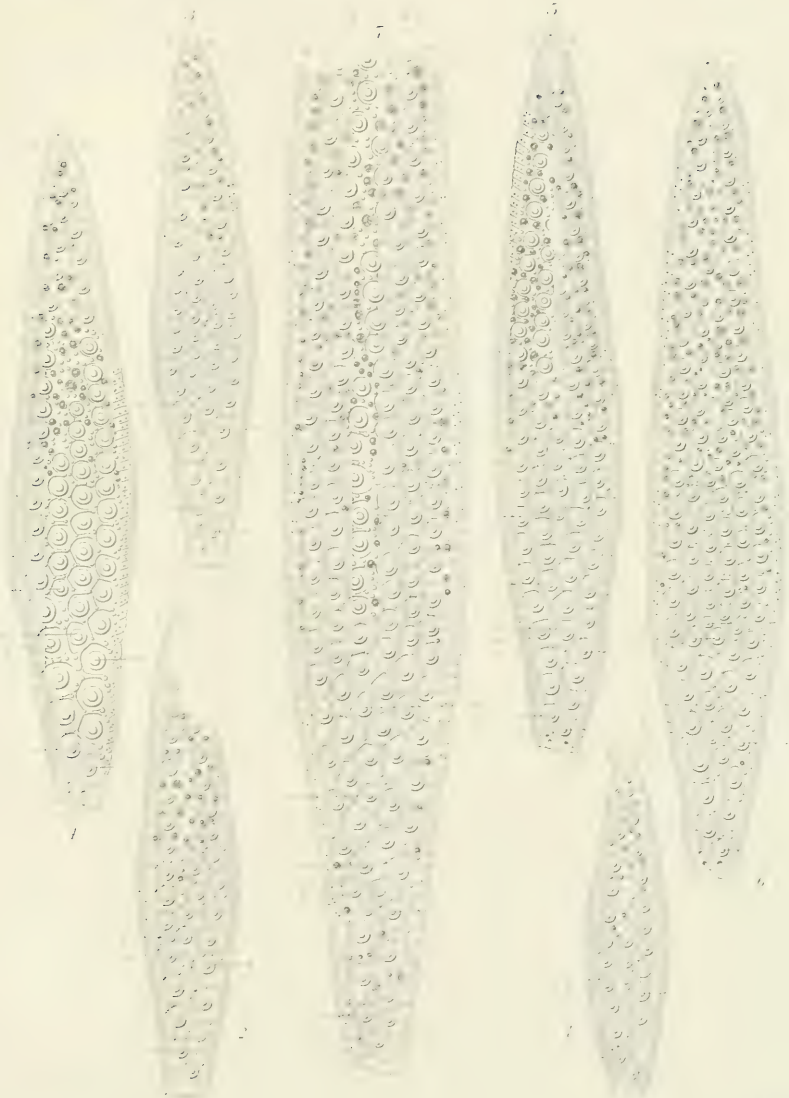


PLATE 25.

PLATE 25.

1–12. **Echinonëus cyclostomus** Leske.

1–8.— Order in which number of primary tubercles increase on the seventh plate from actinostome, including the primordial; from left anterior interambulacrum, bordering on odd anterior ambulacrum, is as follows.

1.— Seventh plate from mouth from a specimen 4.19 mm. long
2.— Seventh plate from mouth from a specimen 6 mm. long.
3.— Seventh plate from mouth from a specimen 8 mm. long.
4.— Seventh plate from mouth from a specimen 10 mm. long.
5.— Seventh plate from mouth from a specimen 12 mm. long.
6.— Seventh plate from mouth from a specimen 15 mm. long.
7.— Seventh plate from mouth from a specimen 17 mm. long.
8.— Seventh plate from mouth from a specimen 26 mm. long.

1–8.— From alcoholic specimens. Port Antonio, Jamaica.

9.— Part of test showing primary and glassy tubercles, from left anterior interambulacrum, fourth plate from actinostome. Diameter of boss 0.35 mm.
10.— Same as previous, from right anterior interambulacrum, midway between ambitus and genital plate. Diameter of boss 0.29 mm.
11.— Half profile of a glassy tubercle, diameter 0.37 mm.
12.— Same in profile, and section of test.

9–12.— From an alcoholic specimen measuring 27 mm. long. Makemo Island, Paumotu Islands.
Figures 1–8, same enlargement.

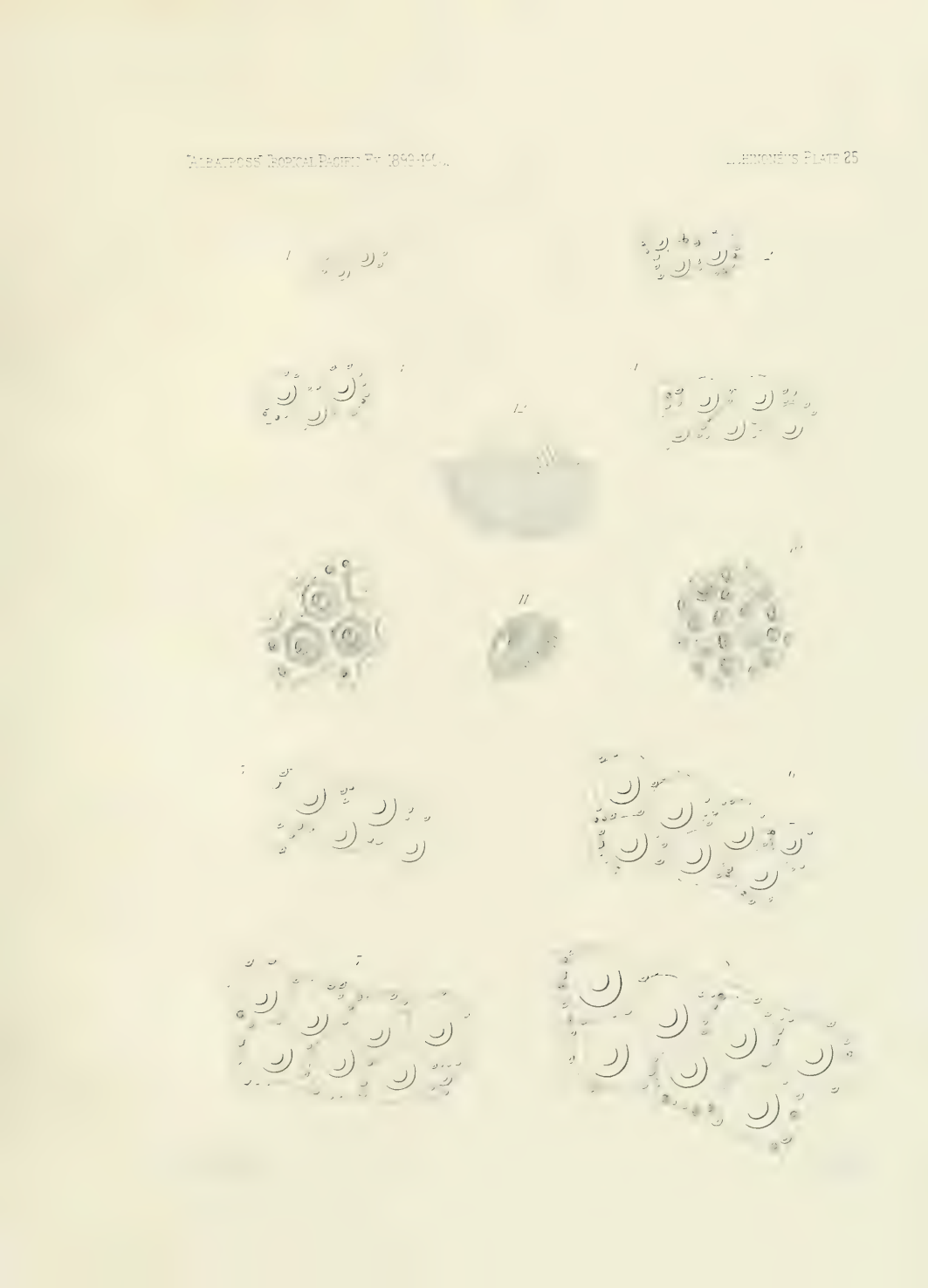


PLATE 26.

PLATE 26.

1–31. **Echinonëus cyclostomus** Leske.

Spines.

1.— Spine, 3.10 mm. long,
2.— Spine, 1.51 mm. long, } from left anterior interambulacrum, near actinostome.
3.— Spine, 1.51 mm. long, detail of Figure 2, edge showing serration.
4.— Spine, 2.30 mm. long, from right posterior interambulacrum, midway between actinostome and ambitus.
5.— Spine, 2.30 mm. long, detail of Figure 4, top view, larger magnification.
6.— Spine, 1.31 mm. long,
7.— Spine, 1.18 mm. long, } from left anterior interambulacrum at ambitus.
8.— Spine, 2.85 mm. long, from odd posterior interambulacrum, near anal system.
9.— Spine, 2.85 mm. long, detail of Figure 8, top view, larger magnification.
10.— Spine, 0.60 mm. long, from left anterior interambulacrum at ambitus.
11.— Spine, 0.60 mm. long, same as Figure 10, larger magnification, showing serrations.
12.— Spine, 2.18 mm. long, base and section of a spine.
13.— Spine, 2.18 mm. long, top view of Figure 12.
14.— Spine, 1 mm. long, from anal system.
15.— Spine, 1 mm. long, same as Figure 14, larger magnification, showing serrations.
16.— Stalk, 0.34 mm. long, of a globiferous pedicellaria, from right anterior interambulacrum, near apical system.
17.— Stalk, 0.34 mm. long, same as Figure 16, larger magnification.
18.— Stalk, 0.44 mm. long, of an ophicephalous pedicellaria, from right anterior interambulacrum, midway between ambitus and apical system.
19.— Stalk, 0.44 mm. long, same as Figure 18, larger magification.

1–19.— Lord Howe Island from a dry specimen, with spines measuring 34 mm. long.
Except for details the enlargement is the same.

20.— Spine, 1.32 mm. long, from right posterior ambulacrum, near actinostome.
21.— Spine, 1.32 mm. long, same as Figure 20, larger magnification.
22.— Spine, 1.90 mm. long, from left posterior ambulacrum, near anal system.
23.— Spine, 1.90 mm. long, same as Figure 22, section of base through milled collar.
24.— Spine, 0.50 mm. long, from right anterior interambulacrum, midway between actinostome and ambitus.
25.— Spine, 0.50 mm. long, same as Figure 24, larger magnification.
26.— Spine, 0.44 mm. long, detail of an end, from right anterior interambulacrum near actinostome.
27.— Spine, 1 mm. long, from right anterior interambulacrum at ambitus.
28.— Spine, 0.72 mm. long, from right anterior interambulacrum, near apical system.
29.— Spine, 0.35 mm. long, from left anterior interambulacrum, near apical system.
30.— Stalk, 0.63 mm. long, of an ophicephalous pedicellaria, from right anterior interambulacrum, near actinostome.
31.— Stalk, 0.63 mm. long, same as Figure 30, larger magnification.

Figures 20–31, Makemo Island, Paumotu Islands, are from an alcoholic specimen, with spines measuring 18 mm. long.
Enlarged slightly more than those from Lord Howe Island.

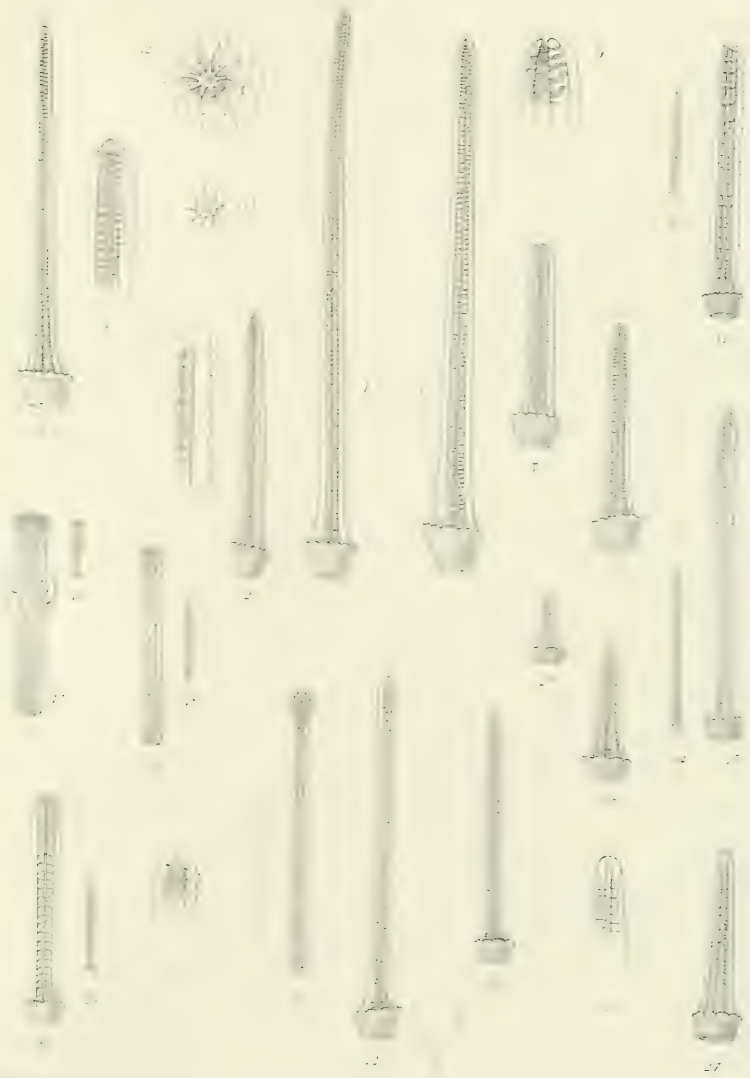


PLATE 27.

1–44. **Echinonëus cyclostomus** Leske.

Spines.

1.— Spine, 1.50 mm. long, from left anterior interambulacrum, near actinostome.
2.— Spine, 1.50 mm. long, outline of serration of Figure 1.
3.— Spine 1.65 mm. long, from odd posterior interambulacrum, near actinostome.
4.— Spine, 2.6 mm. long, from right anterior interambulacrum, midway between actinostome and ambitus.
5.— Spine, 1.22 mm. long, from right anterior interambulacrum, at ambitus.
6.— Spine, 0.82 mm. long, from left anterior interambulacrum, actinal side.
7.— Spine, 0.82 mm. long, detail of Figure 6, top view, larger magnification.
8.— Spine, 0.65 mm. long, from near apical system.
9.— Spine, 0.38 mm. long, from apical system.
10.— Spine, 0.22 mm. long, from the madreporic plate.
11.— Spine, 0.22 mm. long, same as Figure 10, larger magnification.
12.— Stalk, 0.34 mm. long, of an ophicephalous pedicellaria, from left posterior interambulacrum.
13.— Stalk, 0.34 mm. long, same as Figure 12, larger magnification.
14.— Spine, 1.20 mm. long, from right anterior interambulacrum, towards actinostome.

Figures 1–14. Fakarava Island, Paumotu Islands.

Figures 1–8, 12–13, are from an alcoholic specimen with spines measuring 23 mm. long. Figures 9, 10, 11, and 14 from an alcoholic specimen with spines measuring 11 mm. long. The enlargement is same as those on Plate 26 from Makemo Island.

15.— Spine, 1.95 mm. long, from right posterior ambulacrum, near actinostome.
16.— Spine, 2.80 mm. long, from odd posterior interambulacrum, near anal system.
17.— Spine, 2.92 mm. long, from odd posterior interambulacrum, near anal system.
18.— Spine, 1.64 mm. long, from right anterior interambulacrum, at ambitus.
19.— Spine, 1.54 mm. long, from anal system.
20.— Spine, 1 mm. long, from apex.
21.— Spine, 0.42 mm. long, from madreporic plate.
22.— Spine, 0.42 mm. long, same as Figure 21, larger magnification.
23.— Stalk, 0.52 mm. long, of a globiferous pedicellaria, from right anterior interambulacrum, abactinal side.
24.— Stalk, 0.52 mm. long, same as Figure 23, larger magnification.

Figures 15–24, Barbados, (?) are from an alcoholic specimen, with spines measuring 30 mm. long. Enlargement identical with those from Lord Howe Island.

25.— Spine, 1.63 mm. long, from right posterior interambulacrum, near actinostome.
26.— Spine, 2.26 mm. long, from odd posterior interambulacrum, near anal system.
27.— Spine, 1.46 mm. long } from right anterior interambulacrum, at ambitus.
28.— Spine, 1.46 mm. long }
29.— Spine, 1.6 mm. long } from right anterior interambulacrum, near apical system.
30.— Spine, 0.86 mm. long }
31.— Spine, 0.38 mm. long, from madreporic plate.
32.— Spine, 0.38 mm. long, same as Figure 31, larger magnification.
33.— Spine, 1 mm. long, from odd anterior ambulacrum, actinal side.
34.— Spine, 1 mm. long, top of Figure 33, larger magnification.
35.— Stalk, 1.4 mm. long, of an ophicephalous pedicellaria, from left anterior interambulacrum, actinal side.
36.— Stalk, 1.4 mm. long, same as Figure 35, larger magnification.
37.— Spine, 0.56 mm. long, from right anterior interambulacrum, at edge of actinostome.
38.— Spine, 0.78 mm. long, from odd posterior interambulacrum, near anal system.

39.— Spine, 0.77 mm. long, from right anterior interambulacrum, at ambitus.
40.— Spine, 0.54 mm. long, from apex.
41.— Spine, 0.21 mm. long, from madreporic plate.
42.— Spine, 0.21 mm. long, same as Figure 41, larger magnification.
43.— Stalk, 0.32 mm. long, of a globiferous pedicillaria, from right anterior interambulacrum.
44.— Stalk, 0.32 mm. long, same as Figure 43, larger magnification.

Figures 25–44, Port Antonio, Jamaica. Figures 25–36, are from an alcoholic specimen with spines measuring 25 mm. long. Enlargement identical with those of Lord Howe Island. Figures 37–44, alcoholic specimen measuring 4 mm. long, magnified on larger scale.

The position of sections prepared are indicated by dotted line.

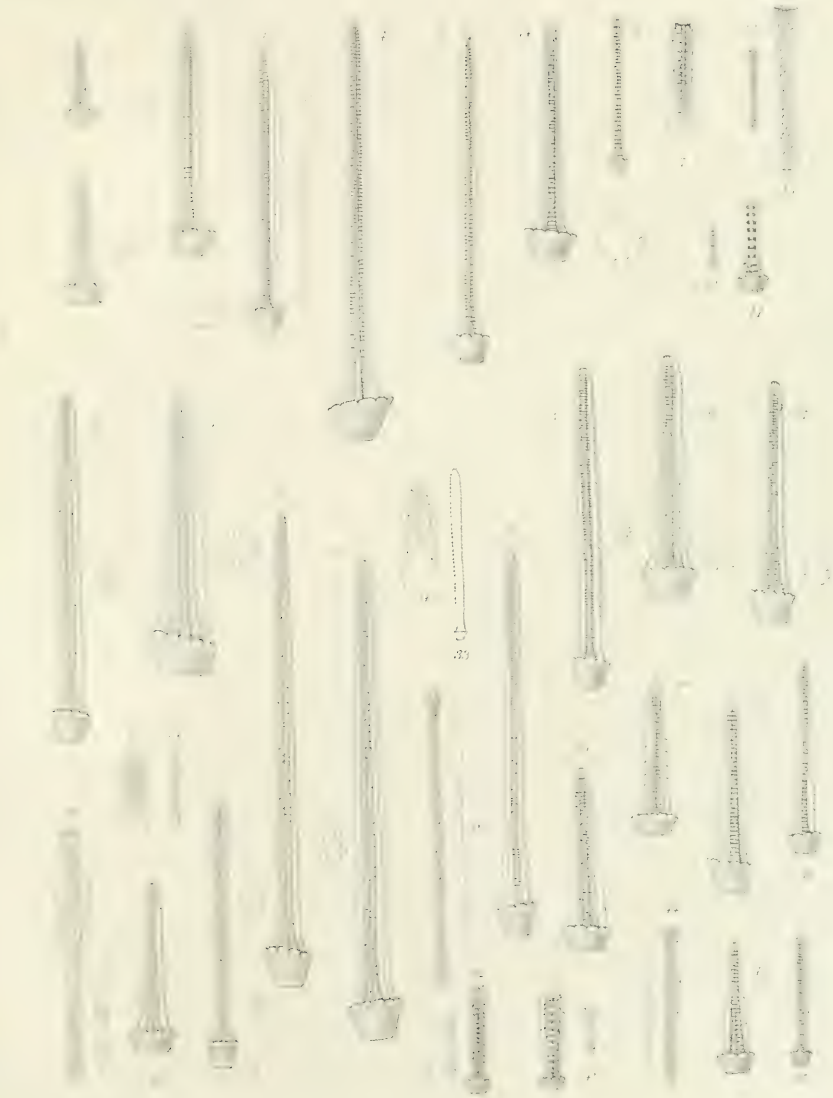


PLATE 28.

PLATE 28.

1–24. **Echinonëus cyclostomus** Leske.

1.— Actinal tube-foot 0.65 mm. long, seen in profile, from near actinostome in odd anterior ambulacrum.
2.— Actinal tube-foot, seen from above the disk, from right anterior ambulacrum.
3.— Profile of an actinal tube-foot, from odd anterior ambulacrum.
4.— Disk plates 0.7 mm. in diameter, seen from above, near actinostome, in odd anterior ambulacrum.
5.— One of the disk plates, whole disk 0.22 mm. in diameter, from right anterior ambulacrum, actinal side.
6.— Disk plates 0.14 mm. in diameter, seen from above, from odd anterior ambulacrum, towards apical system.

Figures 1–3, 5 and 6, are from a test with spines measuring 25 mm. long. Figure 4 from a test with spines measuring 7 mm. long. Port Antonio, Jamaica.

7.— One of the disk plates, seen from below with yoke-shaped spicules, whole disk 0.22 mm. in diameter, from odd anterior ambulacrum actinal side, test with spines measuring 30 mm. long. Barbados (?).
8.— One of the disk plates, from tube-foot near actinostome, left anterior ambulacrum, test with spines measuring 30 mm. long. Barbados (?).
9.— One of the disk plates from tube-foot near actinostome, left anterior ambulacrum, test with spines measuring 26 mm. long. Barbados (?).
10.— Abactinal tube-foot 0.22 mm. long, seen in profile, from near ocular plate, odd anterior ambulacrum, test with spines measuring 12 mm. long. Makemo Island, Paumotu Islands.
11.— Disk plates 0.15 mm. in diameter, seen from above, actinal side, odd anterior ambulacrum, test with spines measuring 12 mm. long. Makemo Island.
12.— One of the disk plates, whole disk 0.20 mm. in diameter, from odd anterior ambulacrum, actinal side, test with spines measuring 18 mm. long. Makemo Island.
13.— Disk plates 0.10 mm. in diameter, seen from above, near the ocular plate, in odd anterior ambulacrum, test with spines measuring 12 mm. long. Makemo Island.
14.— One of the disk plates, whole disk 0.19 mm. in diameter, from odd anterior ambulacrum, actinal side, test with spines measuring 23 mm. long. Fakarava Island, Paumotu Islands.
15.— Peripodium at the edge of actinostome.
16.— Fifth peripodium from actinostome.
17.— Peripodium at the ambitus.
18.— Peripodium near ocular plate.

Figures 15–18, odd anterior ambulacrum, test with spines measuring 34 mm. long. Lord Howe Island.

19.— First and second peripodia at the edge of actinostome, odd anterior ambulacrum, test with spines, measuring 37 mm. long. Mauritius.
20.— Fifth peripodium from actinostome, same specimen as Figure 19.
21.— Peripodium at the edge of actinostome, odd anterior ambulacrum, test without spines measuring 27 mm. long. Pacific (?).
22.— Fifth peripodium from actinostome, same specimen as Figure 21.
23.— Fifth peripodium from actinostome, odd anterior ambulacrum, test with spines measuring 27 mm. long. Makemo Island.
24.— Fifth peripodium from actinostome, odd anterior ambulacrum, test with spines measuring 26 mm. long. Jamaica.

The enlargement of all the figures is not identical.

PLATE 29.

PLATE 29.

1–14. **Micropetalon purpureum** A. Agassiz and H. L. Clark.

1.— Actinal side of a dry specimen, 17 mm. long including spines, from the Hawaiian Islands.
2.— The same from the abactinal side.
3.— The same in profile, facing left anterior interambulacrum and left posterior interambulacrum.
4.— Exterior view of abactinal system, denuded, showing the madreporite and genital pores.
5.— The same as Figure 4, from the interior.
6.— Odd anterior ambulacrum, showing pores and arrangement of primary tubercles and milliaries.
7.— Seventh plate from the edge of actinostome, in left anterior interambulacrum.
8.— Plate from posterior interambulacrum, abactinal side near the apex.
9.— Peripodium, at the edge of actinostome in odd anterior ambulacrum.
10.— Fifth peripodia from the actinostome.
11.— One of the peripodia in the ambitus.
12.— Peripodium near the ocular plate.
13.— Sphaeridium, first from edge of actinostome, in odd anterior ambulacrum.
14.— Second sphaeridia, from same ambulacrum as preceding.

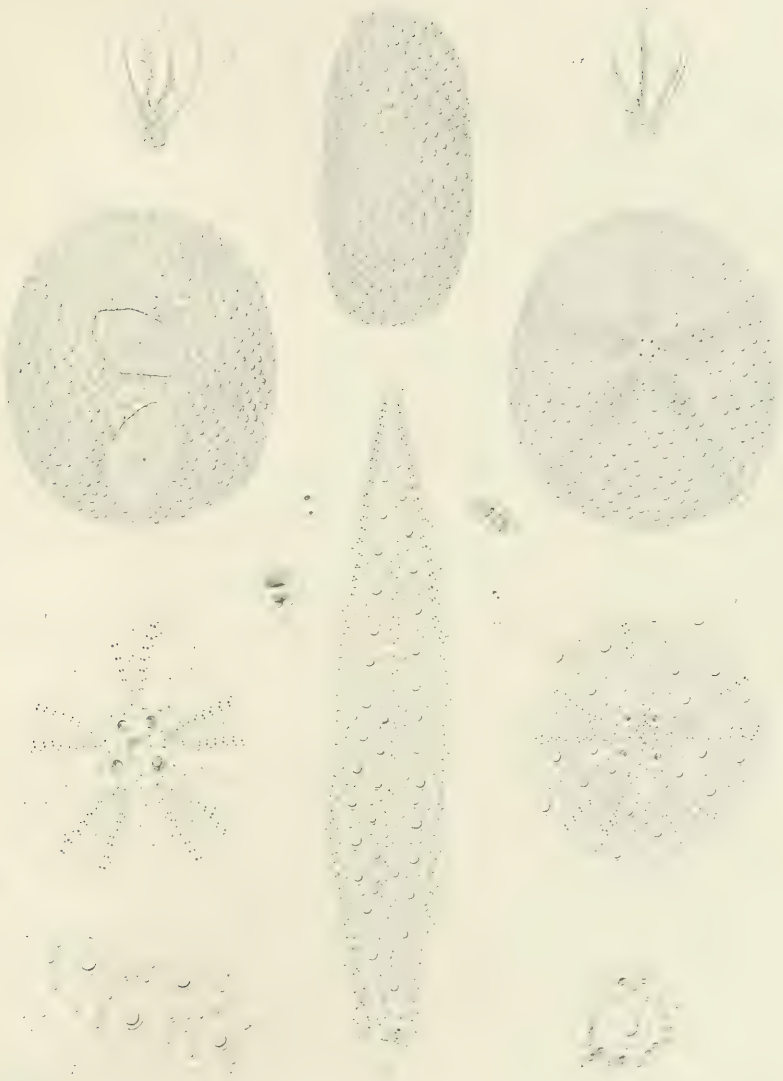


PLATE 30.

PLATE 30.

Micropetalon purpureum A. Agassiz and H. L. Clark.

Arrangement of the coronal plates, seen from inside of a dry specimen, measuring 17 mm. long. Hawaiian Islands.

PLATE 31.

PLATE 31.

1–17. **Micropetalon purpureum** A. Agassiz and H. L. Clark.

1.— Interior view of the actinal side.
2.— Anal system, seen from the outside.
3.— Stalk and head of an ophicephalous pedicellaria, measuring 1.13 mm. long, from the abactinal side, at the ambitus, from the right posterior interambulacrum.
4.— Ophicephalous pedicellariae, 0.27 mm., valve B in centre, from right anterior interambulacrum from the abactinal side.
5.— Valve A, 0.28 mm. exterior view.
6.— Valve B, 0.26 mm. exterior view. } Of a single ophicephalous pedicellaria, from the abactinal side
7.— Valve C, 0.25 mm. interior view. } at the ambitus, from right anterior interambulacrum.
8.— Valve C, 0.25 mm. exterior view, from the right anterior interambulacrum, from the abactinal side.
9.— Spine, 1.92 mm. long, from right anterior interambulacrum, near the edge of the actinostome.
10.— Spine, 1.44 mm. long, from right anterior interambulacrum towards the summit.
11.— Spine, 0.95 mm. long, from odd anterior ambulacrum, at the edge of actinostome.
12.— Spine, 0.65 mm. long, from right posterior interambulacrum, near the summit.
13.— Spine, 0.81 mm. long, detail of an end, from right anterior interambulacrum, from the abactinal side.
14.— Disk plate, 0.21 mm. in diameter, seen from above, from odd anterior ambulacrum, from the actinal side.
15.— Actinal tube-foot, 0.50 mm. long, seen in profile, from the edge of actinostome, in odd anterior ambulacrum.
16.— Abactinal tube-foot, diameter of the disk 0.11 mm. from the apex.
17.— Spicules from the tube.

The magnification is identical in figures of the same order.

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXXIX. No. 3.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, to MARCH, 1905, LIEUT. COMMANDER L. M. GARRETT, U. S. N., COMMANDING.

XXXII.

ASTEROIDEA.

By HUBERT LYMAN CLARK.

WITH SIX PLATES.

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CAMBRIDGE, U. S. A.:
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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross," from October, 1904 to March, 1905, Lieut. Commander L. M. Garrett, U. S. N., Commanding. XXXII. Asteroidea. By Hubert Lyman Clark. With 46 pp. and 6 Plates.

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EASTERN TROPICAL PACIFIC ASTEROIDEA.

INTRODUCTION.

The collections of sea-stars made by the Albatross on her Tropical Pacific expeditions were not large, but as they contained much valuable material from deep water they were entrusted to Prof. Hubert Ludwig, by whom the report on the Panamic collection of 1891 was prepared. The collection made in 1899–1900 contained but forty-two specimens of thirteen species, of which ten were well-known littoral forms while three were deep-sea species, new to science; these thirteen species are included in the Memoir on the Panamic starfishes which was published in 1905 (Mem. M. C. Z., 32). The collection made in 1904–05 was much larger and Ludwig never completed his work on it. In 1907 (Zool. Anz., 31, p. 312–319) he published a preliminary description of five new species and a new variety of Porcellanasteridae, but his study of the other families was unfinished at the time of his death in 1913. Later the collection was sent to Cambridge together with his notes, some of which were apparently in form for publication. It was at first thought that these notes would be of service in the preparation of the present report, but it soon became evident that the correlation between the notes and the collection was too imperfect to permit this. There are notes on species, including descriptions of new forms, which are not in the collection as returned to Cambridge and there are many species in the collection not mentioned in the notes. Under the circumstances therefore, I have decided to base this report exclusively on the collection as returned to Cambridge.

The collection at present consists of 235 specimens of twenty-eight species and one variety, but 148 of the specimens represent three species and four additional species total fifty specimens. Three fourths of the species therefore are represented on an average by fewer than two specimens each. Of the twenty-eight species, six are littoral and twenty-two are deep-water forms. Of the littoral species, five are common and long-known species, while one is of exceptional interest, being a new asteriid from Easter Island. Of the deep-water species, eight are as yet undescribed forms while five others were new to science when the collection was sent to Ludwig; these (as already stated) have been

named and described by him. Of the other nine species, all but one were taken by the ALBATROSS Expedition of 1891.

Half of the deep-water species described as new belong to the Brisingidae, while a fifth member of the family, in this collection, was hitherto known only from the Atlantic Ocean. These facts illustrate well how characteristic of the deep-water fauna the Brisingidae are and how little that fauna is as yet known. It is worthy of note that of the more than a dozen species of Brisingidae now known from the Pacific, not one is in the present collection.

With the increasing knowledge of the deep-sea fauna, several genera of sea-stars have been enlarged by numerous species until it is by no means easy to determine the various forms assigned to them. I have therefore attempted the revision of Hymenaster and Zoroaster. As the latter genus includes the bulk of the Zoroasteridae, the revision is extended to include the other genera and species thereof. Artificial keys to the species which seem entitled to recognition are included. Complete lists of the species proposed up to the present time, in these genera, with the necessary bibliographical references, are also given.

SYSTEMATIC ACCOUNT.

PORCELLANASTERIDAE.

Eremicaster pacificus.

Porcellanaster pacificus LUDWIG, 1905. Mem. M. C. Z., **32**, p. 89.
Eremicaster pacificus FISHER, 1907. Zool. Anz., **32**, p. 14.

These specimens, in which R = 15 and 22 mm., are not peculiar in any way, but agree well with the original material from the Panamic region. I fully agree with Fisher, in dissent from Ludwig, that the number of cribriform organs is a more important, and also a more available, generic character than the presence or absence of the segmental papillae. The bathymetrical range is considerably increased by the present record and the geographical range is extended to the south about 300 miles.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gy. m.

Two specimens.

Eremicaster tenebrarius.

Porcellanaster (*Eremicaster*) *tenebrarius* FISHER, 1905 (10 June). Bull. U. S. Bur. Fish., **24**, p. 293.
Porcellanaster waltharii LUDWIG, 1905 (July). Mem. M. C. Z., **32**, p. 92.
Eremicaster tenebrarius LUDWIG, 1907. Zool. Anz., **31**, p. 318.

This species has been so well-described and figured by Fisher (1911. Bull. 76 U. S. N. M., p. 24–29), and its variations so fully discussed, that nothing of importance can be added. There seems to be no doubt of the identity of *walthariі* and *tenebrarius*. The present series is of interest only because the largest (R = 45 mm.) is somewhat larger than Fisher's specimens and because of the range extension. The bathymetrical range is extended nearly 600 fathoms while the geographical range is extended southward almost 800 miles.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.
Station 4666. Eastern Tropical Pacific, 11° 55′ 30″ S., 84° 20′ 18″ W., 2,600 fms. Bott. temp. 34.9°. Lt. gy. oz.
Station 4672. Peru: southwest of Palominos Light House, 88 miles, 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.
Station 4717. Eastern Tropical Pacific, 5° 11′ S., 98° 56′ W., 2,153 fms. Bott. temp. 35.2°. Rd. c., glob. oz.

Twenty-four specimens.

Eremicaster vicinus.

Plate **2**, fig. 7, 8.

Porcellanaster vicinus Ludwig, 1907. Zool. Anz., **31**, p. 318.
Eremicaster vicinus Fisher, 1907. Zool. Anz., **32**, p. 14.

Although Ludwig's description is very brief, it gives all the essential characters of this species and a detailed account now seems quite superfluous. There is a good series of specimens, ranging from 19 to 32 mm. in diameter and showing little diversity in structure, save in the armature of the superomarginal plates; in three specimens (one from 4670 and the only two individuals from 4672), there are no spines on the superomarginals and these are the ones Ludwig has called "var. *inermis*." One specimen has the terminal third of a ray curiously doubled; seen from above, the abnormal width and the two terminal plates, coalesced along their inner margins, are striking; on the lower surface there are two distinct ambulacral furrows, each with six or seven pairs of tube-feet.

Fisher (1911. Bull. 76 U. S. N. M., p. 30) says that "*vicinus* is insecurely separated from *pacificus*" but I do not think he would feel so if he had compared specimens. Besides the absence of actinal interradial spinelets, *vicinus* has two characteristics which easily separate it from *pacificus*. One of these is found in the adambulacral spines, which are very small (short and slender) and are placed close together at the adoral end of the plate, while the other and more conspicuous is in the spinulation of the oral plates, which have only one, or

sometimes two minute conical spinelets near the center of the margin, instead of 2–5 large, flat spines occupying practically the entire margin. While the abactinal surface of *vicinus* is thus indistinguishable, by any constant character, from that of *pacificus*, the oral surface is separable at a glance.

Station 4670. Peru: west of Palominos Light House, 105 miles, 3,209 fms. Bott. temp. 35.4°. Fne. dk. br. m.
Station 4672. Peru: southwest of Palominos Light House, 88 miles, 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Forty-six specimens.

Ctenodiscus crispatus.

Asterias crispata RETZIUS, 1805. Diss. Ast., p. 17.
Ctenodiscus crispatus DÜBEN AND KOREN, 1846. K. Vet. Akad. Handl. f. 1844, p. 256.

So fully has this well-known species been discussed by earlier writers and particularly by Fisher (1911, Bull. 76 U. S. N. M., p. 31–37), it would be quite superfluous to give space to its diversities here. The series at hand is a large one but from only a single station, and the specimens range in diameter from 15 to 70 mm.

Station 4631. Panama: off Mariato Point, 72 miles, 774 fms. Bott. temp. 38°. Gn. s.

Thoracaster magnus.

Plate **1**, fig. 1, 2.

LUDWIG, 1907. Zool. Anz. **31**, p. 313.

This truly superb species has been sufficiently described by Ludwig, who has also pointed out some of the characteristic differences between it and the genotype, which was taken by the CHALLENGER in the Atlantic in 2,400 fms. Since Ludwig described *magnus*, Koehler has published an account of a third species of the genus, *alberti*, taken by the INVESTIGATOR in the Indian Ocean in 1,504 fms. But *alberti* is obviously different in many particulars from either of the other species, so that the genus contains three very well-marked forms.

The cribriform organs of *magnus* tend to merge together to a very marked degree, and apparently this is a matter of age. For in a specimen with R = 23 mm., these organs are quite distinct and although the three middle pairs are very broad, much wider than the interspaces which separate them, they do not merge at all; the outer pair are so narrow and inconspicuous, one would scarcely consider them cribriform organs. On the other hand in a specimen with R = 73 mm., all fourteen of the organs are more or less merged together; those near the interradius are merged for practically their full height, being

separated by only an insignificant bare elevation on the upper edge of the superomarginal plate, and by a similar low knob about twice as large on the lower edge of the inferomarginals; distally these knobs become gradually longer and more conspicuous, though not noticeably higher, and finally, between the sixth and seventh organs on each side, they permit the merging of the organs only along the line between the upper and lower marginal plates. In large specimens, the low elevations on the inferomarginals bear scattered, small spinelets of diverse sizes.

In another particular, *magnus* differs markedly from the other two species of the genus, and that is in the series of abactinal plates which extends to the tip of the arm or nearly so. In a specimen with R = 23 mm. this series is .60 mm. wide clear to the terminal plate; the plates composing it are of irregular size and form and show no definite arrangement; they are largest distally (but not close to the terminal plate where they are very small) and some of them may be fully .60 mm. across; the larger plates and even the smaller distal ones bear no spinelets but have a smooth, slightly convex surface. In a large specimen, with R = 73 mm., the plates do not reach the extreme tip of the arm, but are shut off from the terminal plate by the meeting of three pairs of superomarginals; the plates are more angular and flatter than in the smaller specimen and their surface is somewhat coarsely shagreened; there is a very abrupt transition from the small spinelet-bearing plates of the disk to the bare median series of the arm; this occurs about 35 mm. from the arm-tip.

The disk and cribriform organs are yellow-brown in the preserved specimens, with all the marginal plates, bare plates of arms and whole lower surface more or less nearly white. In size the range is from R = 23 to R = 98 mm.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 36′ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.
Station 4717. Eastern Tropical Pacific, 5° 11′ S., 98° 56′ W., 2,153 fms. Bott. temp. 35.2°. Rd. c., glob. oz.

Nine specimens.

Styracaster monacanthus.

Plate **2**, fig. **1**, **2**.

Ludwig, 1907. Zool. Anz., **31**, p. 315.

While the original description of this unique specimen is adequate, Ludwig does not discuss its relationship to other members of the genus, although he

himself describes four new species in his relatively brief paper. But the omission is not serious for the present species is notably distinct and might well be made the type of a new genus. It resembles *S. chuni* and *S. paucispinus* in the large disk and short arms; the general facies is thus very different from that of the typical members of Styracaster. But the absence of paxillae and the presence of only five narrow cribriform organs distinguishes *monacanthus* at once from its two nearest allies and these differences are accentuated by the very low and wide interradial marginal plates and the presence of only a single spine on the supramarginal series of plates of each arm. The low, rounded scale-like spines on the margin of the oral plates are an added feature worthy of note. The disk is light gray and the arms and marginal plates are nearly white, in slight contrast.

Station 4701. Eastern Tropical Pacific, 19° 11′ 30″ S., 102° 24′ W., 2,265 fms. Bott. temp. 35.5°. Dk. br. choc. c., mang. nod.

One specimen.

Styracaster paucispinus.

Plate 2, fig. 3, 4.

Ludwig, 1907. Zool. Anz., **31**, p. 315.

Ludwig's description of this species is somewhat more ample than that of *monacanthus* but as in the case of that species, he does not discuss its relationships. It agrees with *S. armatus*, *spinosus*, and *edwardsi* in the possession of only three cribriform organs in each interbrachial arc; in the great breadth of these, *paucispinus* is nearest to *armatus*. But it differs very markedly from all these species, in its very short arms, R equalling 2.5 r or less, whereas in the three other species, R = 3 r or more. Associated with this shortness of arms is a reduction in the number of superomarginal spines which are never more than three to an arm and may be one only; Ludwig says "two or three" but I fail to find more than two in any case; the longest ones are scarcely 2 mm. high and are quite thick at the base. The "winzigen, granuloiden stachelchen" on the ventrolateral plates are so minute as to hardly warrant the name, and in one specimen appear to be quite wanting. The adambulacral plates have a marked depression or shallow furrow on the ventral surface; this runs from the inner adoral corner of the plate, where it is deepest, to the outer aboral corner, where it flattens out entirely.

There is little color left in these specimens, which are nearly white, only the disk and the cribriform organs being more or less brownish.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

Two specimens.

Albatrossia nuda.

Plate **2**, fig. 5, 6.

Albatrossaster nudus Ludwig, 1907. Zool. Anz., **31**, p. 318.

The very small starfish upon which this species is based is unquestionably congeneric with the two somewhat larger specimens upon which *A. semimarginalis* was founded by Ludwig, but the reduction of the inferomarginal plates has not gone so far, and since the disk is almost completely bare of spines, it is probably best to consider the present specimen representative of a different species. But Ludwig's proposed change of the generic name from Albatrossia to Albatrossaster is quite unjustifiable for Albatrossia is a different word from Albatrossa with which Ludwig feared it might be confused. The confusion does not seem probable, but in any case, the International Commission on Nomenclature fully settled the matter in their Opinion 25 (July, 1910), dealing with the identical case of Damesella vs. Damesiella. Albatrossaster must therefore be considered as a synonym of Albatrossia.

The holotype of *A. nuda* is very well-preserved, save for the breakage or loss of the large spines on the terminal plate. R = 7 mm. and r = 4.5. The terminal plate is 1 mm. long and 2 mm. broad, with a deeply concave proximal margin; it carries three spinelets, nearly or quite a millimeter long, one at the middle of the upper margin and one at each of the lower distal corners. The cribriform organ is more than a millimeter wide and the anal tube is nearly a millimeter long. The adambulacral armature consists of two flat, wide, pointed spinelets, subequal or the distal one larger. Two similar spinelets occur on the free lateral margins of the much swollen and conspicuous oral plates; at the inner end of these plates, situated on the suture between them is a single, large, oral spine. Ventrolateral plates, like disk, smooth and without spinelets. Color of disk pale dull reddish; marginal plates nearly white; lower surface tinged with dull reddish.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

One specimen.

ASTROPECTINIDAE.

Dytaster demonstrans.

LUDWIG, 1905. Mem. M. C. Z., **32**, p. 41.

There is a good series of this species, both young (R = 10–25 mm.) and adults (R up to 110 mm.) but Ludwig's very full account, with its numerous figures, leaves no occasion for extended notice. While I agree with Fisher that *demonstrans* is probably identical with *gilberti*, I have not seen specimens of the latter and therefore leave the point for future settlement. The following stations extend the range of *demonstrans* some 500 miles southward, and bathymetrically 150 fms.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

Eighteen specimens.

BENTHOPECTINIDAE.

Pectinaster agassizii.

Cheiraster agassizii LUDWIG, 1905. Mem. M. C. Z., **32**, p. 1.
Pectinaster agassizii LUDWIG, 1910. Sitz. K. Preuss. Akad. Wiss., **23**, p. 449.

These specimens are in rather poor condition and none have the arms unbroken but R ranges from about 40 to 80 mm. Some specimens have a few small pedicellariae on the abactinal surface close to the superomarginal plates at the base of the rays but there are no intermarginal pedicellariae. These specimens, while still *agassizii*, show some approach to Fisher's subspecies *P. a. evoplus* from farther north. The exact locality where they were taken is not certain, but it was probably at

Station 4631. Panama: off Mariato Point, 72 miles, 774 fms. Bott. temp. 38°. Gn. s.

Eleven specimens.

GONIASTERIDAE.

Pseudarchaster pectinifer.

LUDWIG, 1905. Mem. M. C. Z., **32**, p. 106.

These specimens, with R = 60 and 80 mm. respectively, are somewhat intermediate between that originally described by Ludwig and the one discussed

by me in 1913 (Bull. Amer. Mus. Nat. Hist., **32**, p. 192). The number of adambulacrals in proportion to *ten* inferomarginals is either nine or ten, while the number of adambulacral spines is from six to eight, and there are from five to eight spines on the ventral surface of the plate. On the other hand the projecting angle of the adambulacrals is not near the aboral end of the plate, but in the larger specimen is about at the middle and in the smaller is distinctly adoral. Probably these details of the adambulacral plates show considerable diversity in the species.

The armature of the superomarginal plates in the present specimens somewhat resembles that of *P. dissonus* for from four to eight of the granules on the outer (lower) end of the superomarginals in the interbrachial arc are more or less elongated into flattened, bluntly pointed spinelets. But these spinelets do not seem to be encased in "membranous sheaths" nor are they as long as in typical *dissonus*.

Station 4654. Peru: off Aguja Point, 24 miles, 1,036 fms. Bott. temp. 37.3°. Dk. br. m.

Two specimens.

Litonotaster tumidus,[1] sp. nov.

Plate **3**, fig. 3–6.

R = 28 mm.; r = 14 mm.; R = 2 r. Disk pentagonal, the arms arising quite abruptly from the angles. Br. = 6 mm. at base and nearly 2 mm. just before tip. In some specimens, the body is not noticeably pentagonal, the interbrachial arcs being very well-rounded. Thus in a specimen with R = 27 mm., r = 11.5 mm. and br., at the level of the interbrachial arcs, 11 mm., the form is quite evenly stellate. In all cases however, the disk is more or less swollen; in the holotype, the vertical diameter at center of disk is 11 mm. while at the margin the thickness is only 3.5 mm.

Abactinal surface covered by numerous circular or rounded-polygonal, thin plates, .5–1 mm. in diameter, not very firmly united together and hence forming a flexible covering. In each interradius but one, is a circular plate, evidently larger than its neighbors, about 1.3 mm. across; in the fifth interradius is the madreporite, a somewhat tumid, rounded-triangular plate, 1.5 mm. across, adjoined on each of its three sides by a plate about 1 mm. wide and .75 mm. high. Excepting the madreporite, these interradial plates are discernible only in dry specimens. In each radius, at the base of the arm, is a group of

[1] *tumidus* = swollen, in reference to the flexible, puffed upper surface of disk.

4–12 plates, noticeably larger than the others, and among these are the only papulae to be found, but even these are small and inconspicuous. All the abactinal plates are surrounded by a series of small rounded granules; on the disk, the surface of each plate also carries several (3–15) similar granules; these may be crowded but are usually rather well-spaced. On the arms, the granules on the surface of the plates become few and disappear, so that at the tips of the arms, the plates entirely lack them, only the marginal series being present there.

Marginal plates 15 on each side of each ray, or 16 in the inferomarginal series; the plates in the two series are of about equal size or the inferomarginals are somewhat larger than the superomarginals in the interbrachial arc and somewhat smaller at the very tip of the ray. Distally each plate is surrounded by a marginal series of small granules, like those of the abactinal plates, while the surface of the plate is bare, but as one passes towards the interradius, granules appear on the surface and in the interbrachial arc pretty well cover the plates; those on the inferomarginals are larger than those on the upper series and are quite angular and more or less pointed. Terminal plate slightly tumid, smooth, transversely oval, not conspicuous.

Actinolateral plates squarish or polygonal not arranged in very definite series, except one row adjacent to the adambulacrals; the plates of this row are the largest and proximally are more than a millimeter square. They extend out two thirds the length of the arm, beyond which the adambulacrals abut directly on the inferomarginals. All the actinolateral plates are moderately well-covered with spaced, pointed spinelets, considerably larger than the granules of the abactinal surface. Adambulacral plates squarish, proximally about equal to the adjoining actinolaterals but becoming larger (relatively only, of course) at middle of arm. Each plate bears a marginal series of five or usually four subequal, slightly tapered blunt spines, about a millimeter long; immediately external to this marginal series, the surface of the plate is bare, but along the outer margin are 4–8 pointed granules or low spinelets similar to those of the actinolateral plates, but perhaps a little larger; these are arranged in one or often two distinct series. Oral plates large but not very tumid; each carries a marginal series of 10–12 spines similar to those of the adambulacral plates, except that the one at the tip of plate (proximally) is noticeably stouter than the others; on the surface of the plate are 10–14 low spinelets like those of the actinolateral plates but a little larger.

Pedicellariae are exceedingly rare but on each specimen critically examined, one was found; this was composed of two wide, blunt, erect valves, slightly

wider at tip than basally; it occurred on the surface of an adambulacral plate near the middle of the arm. In the smallest specimen, half a dozen of these pedicellariae were found on the actinolateral plates.

Color, in alcohol, light yellow-brown, which dries out to a dingy whitish.

Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.
Station 4672. Peru; southwest of Palominos Light House, 88 miles, 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Twelve specimens.

The holotype is from Station 4672.

The discovery of a second species of Litonotaster is one of the interesting results of the work of the ALBATROSS in the Tropical Pacific, for the genus was hitherto known from only the deep waters of the West Indies, Koehler having shown (1909. INVESTIGATOR Ast., p. 73) that Alcock's (1893. Ann. Mag. Nat. Hist., (6), **11**, p. 90) identification of an Indian starfish as identical with the West Indian form was quite erroneous. The genus seems to be a very well-marked one and the present species shows its distinctive characters perfectly. But the differences between *tumidus* and *intermedius*, the genotype, are obvious, particularly in the three following points: — in *tumidus* the abactinal plates of the ray extend clear to the terminal plate while in *intermedius* this is not the case, the distal superomarginals meeting in the radial line; in *tumidus*, the abactinal plates of the distal part of the ray are more uniformly bare than in *intermedius;* and finally, there are only four or five adambulacral spines in *tumidus* as against seven or eight in *intermedius*.

The present species does not show a great deal of individual diversity except in the body-form, already referred to, which is due to the amount of flattening of the interbrachial arc. The only growth-change noted is the greater granulation of the abactinal plates in the adult. In the smallest specimens (R = 19 mm.) most of the disk-plates and those on the proximal part of the arms, as well as the distal plates on the arms, lack granules on the surface, only the marginal series being present. The madreporite is relatively, as well as actually, very much smaller in the small specimens than in the larger.

Oreasteridae.

Nidorellia armata.

Pentaceros (Nidorellia) armatus Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 277.
Nidorellia armata Verrill, 1867. Trans. Conn. Acad., **1**, p. 280.

A single specimen with R = 85 mm. was brought back from Chatham Island, Galapagos.

Linckiidae.

Linckia guildingii.

Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 285.

A small "comet-form" Linckia, with the main arm 25 mm. long, and the four small arms 8–10 mm., taken at Papeete, Tahiti, seems to be the young of this species.

Pharia pyramidata.

Ophidiaster (Pharia) pyramidatus Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 284.
Pharia pyramidata Sladen, 1889. Challenger Ast., p. 784.

There are three specimens of this common Panamic species from Perico Island, Panama. They are remarkable for the short, stumpy appearance of the arms, which are only about four times as long as thick. R = 90–95 mm.; br. = 23 mm. Closer examination shows that not a single arm has a normal tip but in every case the distal part is missing. Although the injury has healed in each case there is no true regeneration started on any arm. It would be interesting to know whether some fish is a persistent browser on this sea-star at Perico Island.

Echinasteridae.

Henricia gracilis.

Cribrella gracilis Ludwig, 1905. Mem. M. C. Z., **32**, p. 204.
Henricia gracilis Fisher, 1911. Bull. 76 U. S. N. M., p. 270.

Two very small Henricias (R = 10 mm.) are as near to this species as to any and are best regarded as young specimens thereof, particularly since one of the original examples of *gracilis* was taken near the Galapagos Islands in 384 fms.

Station 4642. Galapagos Islands: Hood Island, 4 miles southeast of Ripple Point, 300 fms. Bott. temp. 48.6°. Brk. sh., glob.

Pterasteridae.

Although there are only two specimens of this family in the collection, their identification has necessitated a critical revision of the genus Hymenaster and it has seemed worth while to publish this revision. The first reference to the group in literature occurs in Wyville Thomson's The Depths of the Sea, published in 1873, but it was really the work of the Challenger, in the same and three subsequent years, which revealed what a wide-spread and characteristic deep-sea genus Hymenaster is. Since that day numerous additional species have been taken, until the number which have been named now reaches a total of forty-four. The following list gives these species in their chronological order with the necessary bibliographical references and the locality and depth at which they were first taken.

List of the specific names used with Hymenaster.

pellucidus Wyville Thomson, 1873. Depths of the Sea, p. 120. Faeröe Channel, 580 fms.
nobilis Wyville Thomson, 1876. Journ. Linn. Soc. Zool., **13**, p. 73. 1,099 miles southwest of Australia, 1,800 fms.
membranaceus Wyville Thomson, 1877. The Atlantic, **1**, p. 108.[1] Off Portugal, 1,125 fms.
formosus Sladen, 1882. Journ. Linn. Soc. Zool., **16**, p. 213. 1,099 miles southwest of Australia, 1,800 fms.
pergamentaceus Sladen, 1882. *Ibid.*, p. 215. East of Buenos Ayres, 2,650 fms.
sacculatus Sladen, 1882. *Ibid.*, p. 217. 1,099 miles southwest of Australia, 1,800 fms.
echinulatus Sladen, 1882. *Ibid.*, p. 218. Mid-South Pacific, 2,335 fms.
carnosus Sladen, 1882. *Ibid.*, p. 220. Off Chili, 1,500 fms.
glaucus Sladen, 1882. *Ibid.*, p. 221. Southwest of Suruga Gulf, Japan, 565 fms.
vicarius Sladen, 1882. *Ibid.*, p. 223. Between Juan Fernandez and Valparaiso, 1,375 fms.
infernalis Sladen, 1882. *Ibid.*, p. 224. Mid-North Pacific, 2,900 fms.
caelatus Sladen, 1882. *Ibid.*, p. 225. 1,099 miles southwest of Australia, 1,800 fms.
crucifer Sladen, 1882. *Ibid.*, p. 227. 1,099 miles southwest of Australia, 1,800 fms.
anomalus Sladen, 1882. *Ibid.*, p. 228. North of Tristan da Cunha, 1,425 fms.
latebrosus Sladen, 1882. *Ibid.*, p. 230. Southwest of Australia, 1,950 fms.
porosissimus Sladen, 1882. *Ibid.*, p. 231. Between Juan Fernandez and Valparaiso, 1,375 fms.
graniferus Sladen, 1882. *Ibid.*, p. 233. Between Marion and Crozet Islands, 1,375 fms.
geometricus Sladen, 1882. *Ibid.*, p. 234. Mid-South Pacific, 2,335 fms.
pullatus Sladen, 1882. *Ibid.*, p. 235. Southwest of Admiralty Islands, 1,070 fms.
coccinatus Sladen, 1882. *Ibid.*, p. 238. Between Marion and Crozet Islands, 1,375 fms.
praecoquis Sladen, 1882. *Ibid.*, p. 240.[2] Near Crozet Islands, 1,375–1,600 fms.
modestus Verrill, 1885. Amer. Journ. Sci. ser. 3, **29**, p. 151.[3]. Off southern New England, 1,098–1,451 fms.

[1] It is perhaps debatable whether there is an adequate description in connection with this first use of the name, but as the points mentioned would probably distinguish the species from the only other Hymenasters known at the time, it may be just as well to let the name continue to rest on Wyville Thomson's authority.

[2] These eighteen species described by Sladen, as well as the three named by Wyville Thomson, are fully illustrated in Sladen's Challenger Asteroidea, issued in 1889.

[3] It is doubtful whether this description is adequate. A much better one appeared in 1894, Proc. U. S. N. M., **17**, p. 277.

giganteus SLADEN, 1891. Proc. Roy. Irish Acad., ser. 3, **1**, p. 696. Southwest of Ireland, 750 fms.
giboryi PERRIER, 1894. Travailleur et Talisman Stell., p. 189. Between Azores and Europe, 2,218 fms.
rex PERRIER, 1894. *Ibid.*, p. 186.[1] Eastern North Atlantic, 623–1,248 fms.
regalis VERRILL, 1895. Amer. Journ. Sci. ser. 3, **49**, p. 203. Off southern New England, 1,374 fms.
regalis var. *agassizii* VERRILL, 1899. Trans. Conn. Acad., **10**, p. 221. Off southern New England, 1,242 fms.
perspicuus LUDWIG, 1903. Belgica Seesterne, p. 30. Antarctic Ocean, southwest of Alexander the First Land, 222–250 fms.
quadrispinosus FISHER, 1905. Bull. U. S. Bur. Fish., **24**, p. 315. Off San Diego, Cal., 1,059 fms.
platyacanthus LUDWIG, 1905. Mem. M. C. Z., **32**, p. 191. Panamic region, 1,359–1,572 fms.
purpureus LUDWIG, 1905. *Ibid.*, p. 194. Between Cocos Island, and Panama, 1,470 fms.
violaceus LUDWIG, 1905. *Ibid.*, p. 196. Southeast from Acapulco, Mexico, 1,877 fms.
gracilis LUDWIG, 1905. *Ibid.*, p. 198. Panamic region, 1,321–1,771 fms.
pentagonalis FISHER, 1906. Hawaiian Starfishes, p. 1099. Hawaiian Islands, 289–334 fms.
roseus KOEHLER, 1907. Bull. Inst. Ocean., no. 99, p. 21. Eastern North Atlantic, 1,009–1,148 fms.
campanulatus KOEHLER, 1908. Trans. Roy. Soc. Edinburgh, **46**, p. 550. Weddell Sea, 1,410 fms.
densus KOEHLER, 1908. *Ibid.*, p. 554. Weddell Sea, 2,620 fms.
edax KOEHLER, 1908. *Ibid.*, p. 552. East of South Orkney Islands, 1,775 fms.
fucatus KOEHLER, 1908. *Ibid.*, p. 553.[2] Weddell Sea, 1,410 fms.
alcocki KOEHLER, 1909. Investigator Deep Sea Ast., p. 110. East side, Bay of Bengal, 643 fms.
koehleri FISHER, 1910. Ann. Mag. Nat. Hist., ser. 8, **5**, p. 170. Bering Sea, 1,771 fms.
perissonotus FISHER, 1910. *Ibid.*, p. 170. Off San Diego, California, 984 fms.
bartschi FISHER, 1916. Proc. Biol. Soc. Washington, **29**, p. 29. Sulu Sea, 1,105 fms.
rhodopeplus FISHER, 1916. *Ibid.*, p. 29. Gulf of Tomini, Celebes, 834 fms.

The form which Verrill described as a variety (*agassizii*) of *regalis* seems undoubtedly a valid species as it differs from *regalis* in several fundamental points.

The characters which seem of the most importance in distinguishing the species of Hymenaster are the armature of the oral plates and of the adambulacral plates. In most species the number of adambulacral spines, of oral spines, and of suboral spines is remarkably constant. In a few cases, we find three adambulacral spines where the typical number is two, or four where three is usual, and if the number of oral spines is three, there may occasionally be four, while if the number is usually four or five it may run up to seven. The number and form of the suborals is less liable to diversity, but owing to slight shifts of position or some diversity in size, it is often difficult to decide whether the spine nearest the inner end of the oral plate is a suboral or the innermost oral. Careful consideration of its relation to the other orals will generally determine the point however. Thus in *carnosus*, Sladen says there are two suborals but admits that the inner is perhaps an oral; his figure shows that it is best considered the innermost oral. In *quadrispinosus* Fisher, it is possible, as that author

[1] These two species of Perrier were named and the names were published in 1885 but with no description or figures; the names therefore must date from 1894.

[2] These four species of Koehler were mentioned and named in 1907, Zool. Anz., **32**, p. 144, but as the diagnoses are wanting or wholly inadequate, the names must date from the full report. The *Hymenaster scotiae* of the 1909 Zoological Record is a slip of the pen for *Hyphalaster scotiae*.

says, that the innermost oral should be considered a suboral but I have not the material to determine the point. In using the following key to the species of Hymenaster, these possible variations in number of adambulacral, oral, and suboral spines must be kept in mind and when there is any doubt both alternatives should be followed out. The key includes not only all the species listed above, but also the two new forms described below, each of which has some very distinctive characters. Of course the accumulation of more material will bring out defects in the present key, but it will serve as a beginning for a satisfactory brief expression of the taxonomy of the genus. It will be noticed that some of the characters which were considered of primary importance by Sladen, such as the reticulation of the supradorsal membrane, and the body-form, are here either ignored entirely or relegated to a very subordinate position. This has been done because these characters vary so much with the condition of the specimen, as to be of doubtful value. Most Hymenasters are secured only by dredging or trawling in very deep water and they reach the surface in a more or less contracted, contorted, and often damaged condition. It is therefore often impossible to determine what the form and appearance in life were. Since the calcareous parts are less likely to be altered by capture and preservation, I have sought to use these as far as possible in distinguishing the species. Probably this leads to a more artificial arrangement than if *all* the characters could be considered but under existing conditions any arrangement of the species of so little-known a genus must be more or less non-phylogenetic.

Key to the species of Hymenaster.

A. Adambulacral armature of one spine.
  B. Suboral spine single.
    C. Oral spines 2 ..... *cremnodes.*
  CC. Oral spines 3 or 4.
    D. Spiracula not in definite circumscribed areas, except for regular transverse bands on interbrachial membrane; oral spines nearly as long as jaws ..... *nobilis.*
    DD. Spiracula in definite circumscribed areas but transverse bands on interbrachial membrane replaced by small, detached, scattered areas; oral spines about half as long as jaw or less ..... *kochleri.*
  BB. Suboral spines 2 on each plate.
    C.[1] Oral spines 2 ..... *formosus.*
  CC.[1] Oral spines 3 or 4.
    D.[1] Actinolateral membrane thin with very long actinolateral spines; spiracula very small in widely scattered groups of 6–10 ..... *pergamentaceus.*
    DD.[1] Actinolateral membrane thick with short or moderately long actinolateral spines buried in it; spiracula moderately large in irregular groups of usually more than 10.
      E. Suboral spines acicular ..... *rhodopeplus.*
      EE. Suboral spines thick, stout, sacculate ..... *violaceus.*
AA. Adambulacral armature of more than one spine.

B.[1] No true suboral spines though the innermost of the 3 orals might be so considered.....*trias*.
BB.[1] Suboral spines present.
C.[2] No small marginal spines on oral plates.
D.[2] 3 large, subequal spines on each oral plate (all suborals or 2 suborals + 1 oral).....*edax*.
DD.[2] 2 large spines on each oral plate (both suborals or 1 suboral + 1 oral).
E.[1] Valves of osculum with 5 or 6 spines; paxillae with 5–8 spinelets; color yellowish white.
campanulatus.
EE.[1] Valves of osculum with 10 spines; paxillae with 4 spinelets; color dark or at least dusky.
purpureus.
CC.[2] Marginal spines (orals), smaller than suborals, present on oral plates.
D.[3] Suboral spine single.
E.[2] Adambulacral spines 2; membranes fleshy; spiracula very small and grouped; orals 4–6.
F. Suboral spine like a segmental papilla.....*pentagonalis*.
FF. Suboral spine not like a segmental papilla.....*carnosus*.
EE.[3] Adambulacral spines more than 2.
F.[1] Rays attenuate, R = about 2 r; adambulacral spines 3.....*geometricus*.
FF.[1] Rays not at all attenuate.
G. Orals 3, stout; third or fourth actinolateral spine longest.....*coccinatus*.
GG. Orals 4 or 5, slender.
H. Fifth or sixth actinolateral spine longest; adambulacral spines 3 or 4, not in a continuous series.....*modestus*.
HH. Seventh to eleventh actinolateral spines longest; adambulacral spines 4 or 5 in a continuous series.....*quadrispinosus*.
DD.[3] More than one suboral to a plate.
E.[3] Suboral spines 2 on each plate.
F.[2] Only 2 adambulacral spines (3 on some plates, in *perissonotus*).
G.[1] Only 2 orals.....*giboryi*.
GG.[1] 3 or more orals.
H.[1] Paxillar spinelets few, rarely more than 5, often 3.
I. Orals 3.
J. Actinolateral spines rather short, robust, eighth or ninth longest...*echinulatus*.
JJ. Actinolateral spines very long, twentieth to twenty-second longest.
giganteus.
II. Orals 4–7.
J.[1] Of actinolateral spines, fifth to twelfth longest.
K. More or less pentagonal; paxillar spinelets 4 or 5; orals 4.....*roseus*.
KK. More or less stellate; paxillar spinelets usually 3; orals 5.....*agassizii*.
JJ.[1] Of actinolateral spines, twelfth to twenty-first longest.
K.[1] Of actinolateral spines, twentieth or twenty-first longest.....*sacculatus*.
KK.[1] Of actinolateral spines, eighteenth or earlier longest.
L. Paxillar areas of rays conspicuously elevated; actinolateral spines short, stout.....*glaucus*.
LL. Paxillar areas not conspicuously elevated; actinolateral spines long, slender.
M. Paxillar spinelets 3 or 4; on some plates, 3 adambulacral spines.
perissonotus.
MM. Paxillar spinelets 4–6; only 2 adambulacral spines.....*vicarius*.
HH.[1] Paxillar spinelets many, 5–12.
I.[1] Paxillar spinelets 5–7.....*pellucidus*.
II.[1] Paxillar spinelets 8–12.
J.[2] Form pentagonal.....*perspicuus*.
JJ.[2] Form stellate.....*infernalis*.
FF.[2] More than 2 adambulacral spines, except on individual plates or near tip of ray.
G.[2] Color deep purple, with fibrous bands in supradorsal membrane and tips of tube-feet, white; adambulacral spines 3, short, thick subequal.....*pullatus*.[1]
GG.[2] Not as above.
H.[2] Orals 2; paxillar spinelets 5–7; adambulcral spinelets 3–5; fifth actinolateral spine longest.....*praecoquis*.

[1] Sladen's figure shows 4 oral spines but in his description he distinctly says there are only two.

HH.[2] Orals 3–5.
I.[2] Paxillar spinelets 4–7; valves of osculum with 15 spines; actinolateral spines 18, with eighth or ninth longest; adambulacral spines usually 3, the innermost smallest, but sometimes 4, the 2 inner smallest ..... *gracilis.*
II.[2] Not as above.
J.[3] Adambulacral spines 3.
K.[2] Orals only 3.
L.[1] Valves of osculum duplicated by a smaller external series ..... *alcocki.*
LL.[1] Valves of osculum not duplicated.
M.[1] Paxillar spinelets 4 or 5.
N. Paxillar crowns forming raised areas and sharply defining the rays. *caelatus.*
NN. Paxillar crowns not forming raised areas and not defining rays clearly ..... *latebrosus.*
MM.[1] Only 1 well-developed paxillar spinelet ..... *regalis.*
KK.[2] Orals more than 3.
L.[2] Suborals short and wide (or thick).
M.[2] Adambulacral spines very unequal; supradorsal membrane with numerous minute granules ..... *graniferus.*
MM.[2] Adambulacral spines subequal; supradorsal membrane without granules ..... *membranaceus.*
LL.[2] Suborals more or less elongate and tapering.
M.[3] Adambulacral spines very unequal; rays conspicuously defined dorsally ..... *rex.*
MM.[3] Adambulacral spines subequal.
N.[1] Tenth to seventeenth actinolateral spine longest.
O. Inner (proximal) pair of suborals the longest.
P. Orals 4 subequal; outer suboral stouter than inner, shorter but not greatly so ..... *bartschi.*
PP. Orals 5, the two inner ones much larger; outer suboral much smaller in every way than inner ..... *porosissimus.*
OO. Outer (distal) pair of suborals much the longest ..... *crucifer.*
NN.[1] Sixth actinolateral spine longest; suborals subequal ..... *fucatus.*
JJ.[3] Adambulacral spines 4.
K.[3] Paxillar spinelets 3–5; orals 4 ..... *platyacanthus.*
KK.[3] Paxillar spinelets 5–6; orals 3 ..... *densus.*
EE.[3] Suboral spines 3 on each plate ..... *anomalus.*

Hymenaster cremnodes,[1] sp. nov.

Plate 4, fig. 1.

Rays 5. R = 27 mm.; r = 24 mm.; R = 1.125 r. In its present contracted bell-shape, the specimen is nearly 27 mm. high and about 18 mm. in diameter at the mouth of the bell. Paxillae in three series along each ray with an additional partial row along each side of base of ray. Paxillar spinelets 5 or 6 rather long, longer than stalk of paxilla; each spinelet has a thickened cap of skin over its tip, these caps forming conspicuous little blunt cones all over the dorsal surface. Spiracula numerous, rather large, irregularly scattered. Osculum large, about 10 mm. across; each valve with about a dozen spines,

[1] *κρημνώδης* = steep, in reference to the remarkable form of the jaws.

which are clothed, distally at least, with thick opaque skin; the middle spines are about twice as long as the most lateral. In each interradius is a notch about a millimeter deep, on each side of which the interbrachial membrane forms a slightly convex lobe well-supported by the actinolateral spines whose distal ends are covered with thick opaque skin. The triangular interbrachial area is about 10 mm. deep (along the interradius) and in its present contracted condition about 6–8 mm. wide along the free margin. Actinolateral spines about fifteen, of which the third or fourth seems to be the longest; the thick skin in which the spines are somewhat imbedded and the shape and condition of the specimen prevent exact determination of these points. Adambulacral armature consists of a single, acicular spine, about 3 mm. long and not at all sacculate. Aperture papillae nearly sessile, rounded triangular, not as wide as high and scarcely one third the length of the adambulacral spine. Oral plates fused to form a jaw whose length, breadth, and height (distally) are about equal; the slope from the distal end of the keel to the inner tip of the jaw is exceptionally steep; the breadth of the whole jaw, distally is probably considerably more than the height but this is hard to determine; on the outer distal corner of each oral plate are two slender oral spines 1.5–2 mm. long and just below the middle of the surface of each plate is a suboral spine about 3 mm. long and very similar to the adambulacral spines; none of these spines is at all sacculate. Color of supradorsal membrane dull bluish except where it is thickened over the tips of spinelets and spines; in such places it is yellowish white; oral surface nearly black except the interbrachial membrane between the tips of the rays which is contrastingly yellowish white.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

One specimen.

It is difficult to determine how much of the extraordinary bell-shape of this curious Hymenaster is due to contraction caused by its capture and preservation. The bell is much deeper and narrower than in Koehler's *campanulatus* and the rays do not project noticeably beyond its margin. If this were the normal form of the animal in life, the tube-feet on the proximal half of the rays would be useless; indeed progression would have to be by swimming freely in the water. It is very probable that the form of the preserved specimen is quite unnatural and is due to extreme contraction of the interbrachial areas especially along their margins. The armature of the adambulacral and oral plates is very distinctive and the coloration is also peculiar, the heavy pigmentation of the

oral surface being quite unusual. The very high and steep jaws are no less remarkable, so that entirely apart from the peculiar shape the species will be easily recognized when next it is taken.

Hymenaster trias,[1] sp. nov.

Plate **3**, fig. 1, 2.

Rays 5. R = 40 mm.; r = 28 mm.; R = 1.43 r. Body highly arched, the vertical diameter at center being about 20 mm. but this may be due in part to marginal contraction. Form distinctly stellate, the interbrachial arcs being rather deep and angular. Rays quite acuminate, the free narrow tip, about 8 mm. long, being turned up against the aboral surface of the ray. Paxillae covering the whole dorsal surface, the interbrachial areas, as seen from above, practically wanting. Paxillar spinelets five to eight usually six, longer than stalk, very slender and projecting through the thin supradorsal membrane for nearly or quite half their length. Spiracula fairly numerous, quite large, irregularly scattered. Osculum large, about 10 mm. across; each valve with twelve to fourteen spines of which the outermost are shortest but are about three fourths or at least two thirds as long as the middle ones. Actinolateral spines few and widely spaced; there are about sixteen of which the fifth is longest. The membrane in which they lie is thin and transparent. Adambulacral armature consists of two well-spaced, subequal, slender, brittle spines, 4–5 mm. long; the tip is blunt and the spines are not at all sacculate. Aperture papilla distinctly stalked, the blade about as wide as high, except that the upper margin has more or less of a membranous extension, which is, however, never very great. Oral plates united to form a very wide jaw, the width being considerably more than twice the length; the median keel is quite conspicuous but slopes gradually to the inner tip which is wide and rounded; each plate carries three oral spines, of which the innermost is as long as the jaw, or longer, and stands a trifle back from the margin and the outermost is about two thirds as long and stands on the margin near the outer proximal corner of the plate; the middle spine is intermediate in size and position. There is no suboral spine. None of the spines are sacculate. Color, both above and below, pale yellowish.

Station 4672. Peru: southwest of Palominos Light House, 88 miles, 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

One specimen.

[1] τριάς = three, in reference to the armature of the oral plates.

The absence of any suboral spines distinguishes this species from any hitherto described. The three oral spines are so perfectly graduated in size and position, it would be quite unnatural to call the innermost a suboral, even though its position is not strictly marginal. Other notable features of this form are the greatly projecting paxillar spinelets, the few, slender, and widely spaced actinolateral spines, and the very long and slender adambulacral spines.

Zoroasteridae.[1]

The systematic position of this small but well-marked family has been the source of no little difference of opinion, but few will now question the position assigned it by Verrill and by Fisher in the Forcipulosa near the Asteriidae. More than thirty species have been assigned to Zoroaster but the remaining genera are either monotypic or contain only two or three species. As I have had occasion to study critically the forms referred to Zoroaster, I give here a list of such species, followed by artificial keys to the genera which it seems desirable to recognize, and to the species which they contain, when not monotypic.

List of the specific names used with Zoroaster.

fulgens Wyville Thomson, 1873. Depths of the Sea, p. 154. Northwest of the Hebrides, 767 fms.[2]
sigsbeei [3] Perrier, 1880. Comp. Rend., **91**, p. 436. Off St. Kitts, B. W. I., 120–231 fms.
ackleyi Perrier, 1880. *Ibid.*
diomedeae Verrill, 1884. Amer. Journ. Sci., ser. 3, **28**, p. 217. Off southern New England, 1,000–1,600 fms.
longicauda Perrier, 1885. Ann. Sci. Nat., ser. 6, **19**, no. 8, p. 19. Eastern North Atlantic, 1,637–2,325 fms.
tenuis Sladen, 1889. Challenger Ast., p. 421. North of New Guinea, 1,070 fms.
alfredi Alcock, 1893. Ann. Mag. Nat. Hist., ser. 6, **1**, p. 102. Bay of Bengal, 1,300–1,380 fms.
barathri Alcock, 1893. *Ibid.*, p. 103. Bay of Bengal, 1,520 fms.
planus Alcock, 1893. *Ibid.*, p. 104. Laccadive Sea, 1,200 fms.
angulatus Alcock, 1893. *Ibid.*, p. 105. Gulf of Manaar, 597 fms. Laccadive Sea, 705 fms.
carinatus Alcock, 1893. *Ibid.*, p. 107. Andaman Sea, 130–250 fms.
gilesii Alcock, 1893. *Ibid.*, p. 108. Andaman Sea, 400–500 fms.
squameus Alcock, 1893. *Ibid.*, p. 109. Laccadive Sea, 1,043 fms.
zea Alcock, 1893. *Ibid.*, p. 110. Gulf of Manaar, 597 fms. Laccadive Sea, 1,200 fms.
trispinosus Koehler, 1895. Rev. Biol. Nord France, **7**, no. 12, p. 6. Bay of Biscay, 360 fms.
ophiurus Fisher, 1905. Bull. U. S. Bur. Fish., **24**, p. 315. Off San Diego, Cala., 1,059 fms.

[1] Since this report was prepared, Fisher has published two important papers bearing on the morphology and taxonomy of this family: 1919, Ann. Mag. Nat. Hist., ser. 9, **3**, p. 387–393; 1919, Bull. 100 U. S. N. M., p. 470–487. As our results have been reached quite independently and are almost invariably in accord, I have let this account of the Zoroasteridae stand with very few changes.

[2] An unfortunate typographical error on p. 152 gives this locality as "2° 11′ W. long." On p. 144 however, it is correctly given as "9° 11′ W."

[3] The name is spelled "*Sigsbeci*" in the original publication but this is, of course, a typographical error.

sacculatus FISHER, 1905. *Ibid.*, p. 316. Monterey Bay, Cala., 916 fms. See Myxoderma.
evermanni FISHER, 1905. *Ibid.*, p. 317. Between San Diego and San Clemente Island, Cala., 500–507 fms.
magnificus LUDWIG, 1905. Mem. M. C. Z., **32**, p. 159. Gulf of Panama, 1,671 fms.
nudus LUDWIG, 1905. *Ibid.*, p. 164. Gulf of California, 998 fms.
hirsutus LUDWIG, 1905. *Ibid.*, p. 172. South of Acapulco, Mexico, 1,878 fms.
longispinus LUDWIG, 1905. *Ibid.*, p. 180. Eastern Tropical Pacific, 780–1,320 fms.
spinulosus FISHER, 1906. Bull. U. S. Fish Comm., 1903, p. 1102. Hawaiian Islands, 328–557 fms.
bispinosus KOEHLER, 1909. Princesse-Alice Ech., p. 316. No locality given.
adami KOEHLER, 1909. Investigator Deep Sea Ast., p. 108. Bay of Bengal, 569 fms.
platyacanthus H. L. CLARK, 1913. Bull. Amer. Mus. Nat. Hist., **32**, p. 199. Off west coast of Lower California, 284 fms.
ophiactis FISHER, 1916. Proc. Biol. Soc. Wash., **29**, p. 29. Gulf of Tomini, Celebes, 834 fms.
microporus FISHER, 1916. *Ibid.*, p. 30. Southwest of Amblan Island, Moluccas, 700 fms.
carinatus philippinensis FISHER, 1916. *Ibid.*, p. 30. Sibuko Bay, Borneo, 415 fms.
macracantha H. L. CLARK, 1916. Endeavour Ech., p. 68. Great Australian Bight, 250–450 fms.
actinocles FISHER, 1919. Ann. Mag. Nat. Hist., ser. 9, **3**, p. 390. Aleutian Islands, 1,217 fms.
evermanni mordax FISHER, 1919. *Ibid.*, p. 390. Off Washington, 477 fms.

Of the above species, *tenuis* and *longispinus* are based on very young specimens, in which the real specific characters are as yet undeveloped. It is useless to attempt to compare them with the adults of other species and they are therefore omitted from the keys. Until adults are collected, accompanied by young and intermediate stages, these two names are of little service. Ludwig (1905. Mem. M. C. Z., **32**, p. 177) has described another young Zoroaster but he refrained from giving it a name. Koehler's record (1908. Scotia Ech., p. 566) of *tenuis* from 1,742 fms. in the extreme South Atlantic Ocean merely shows that the *genus* ranges that far south. It is highly improbable that his specimen is conspecific with Sladen's type of *tenuis*. Of course, *bispinosus* is only a slip of the pen for *trispinosus*.

The remaining twenty-nine species include several groups which seem to be worthy of rank as distinct genera. First of these is Mammaster, proposed by Perrier in 1894 (Travailleur and Talisman Stell., p. 125) with *Z. sigsbeei* as the type. There is little doubt that the genus is very nearly related to Cnemidaster as that group now stands, thanks to Fisher's investigations (1919. Bull. 100 U. S. N. M., p. 480–484). But I do not think it will ever be necessary "to merge the two genera" as Fisher suggests. For there is a rather striking character, hitherto apparently overlooked, which distinguishes Mammaster at once from any of the known species of Cnemidaster. This is given below in the key to genera and while it may not be of great morphological importance, it affects very evidently the general appearance of the disk. The ALBATROSS collections in the Philippines have revealed so well the growth-stages of Cnemidaster that we can now delimit that group of East Indian and Pacific species very well.

While Mammaster remains monotypic, the following species are to be referred to Cnemidaster: — *wyvillei, squameus, zea, nudus.*

At the same time that he proposed Mammaster, Perrier also seems to propose a new genus, Prognaster, with *Z. longicauda* as the type. He had however, three years earlier (1891. Mem. Soc. Zool. France, **4**, p. 259) given the same name and diagnosis to a genus with a new species, *grimaldii*, as the type. This earlier publication of the name is only referred to casually and ambiguously in the later paper, the user of the Travailleur and Talisman Report being thus completely and quite needlessly misled. The discovery of the many long-armed Zoroasters of the Indian Ocean has made the proposed genus as represented by *longicaudus* quite untenable and I am not able to find any satisfactory basis for separating that species from the more typical species of Zoroaster. But if Perrier is correct in his statement regarding *grimaldii* that the adambulacral plates are all alike, the genus Prognaster may well be retained for so unique a zoroasterid.

In 1905, Fisher (Bull. U. S. Bur. Fish., **24**, p. 316) proposed a subgenus Myxoderma for two new Zoroasters, *sacculatus* and *evermanni*, designating *sacculatus* as the type. This group, to which *platyacanthus* H. L. Clark also belongs, is well-characterized and Fisher has recently (1919. Ann. Mag. Nat. Hist., ser. 9, **3**, p. 387) given it full generic rank. But *evermanni* proves to be a true Zoroaster. Another genus described by Fisher (1916. Proc. Biol. Soc. Washington, **29**, p. 31) is Bythiolophus, based on material collected by the Albatross in Buton Strait, Celebes. This seems to be quite distinct from anything hitherto known in the family. Finally mention must be made of Sladen's (1889. Challenger Ast. p. 426) genus Pholidaster, recently rediscovered by the Albatross.

There are then seven apparently valid genera of Zoroasteridae.

Key to the genera of Zoroasteridae.

A. Primary plates and usually additional disk-plates conspicuously large, convex (often swollen), and more or less bare.

B. First carinal plate, just distal to primary radial, conspicuously enlarged, larger than the adjoining *second* marginals which are very much larger than the first ones; adradials wanting; three series of actinolaterals with beginnings of a fourth in large specimens. . . . . *Mammaster.*

BB. First carinal scarcely or not at all larger than the *first* marginals which are evidently larger than the second; adradials present; four or five series of actinolateral plates. . . . . *Cnemidaster.*

AA. Disk-plates not conspicuously convex or swollen, or if so, closely covered with spinules.

B.[1] Adambulacral plates all alike. . . . . *Prognaster.*

BB.[1] Every other adambulacral plate with a conspicuous ridge projecting into furrow and carrying long spines.

C. Carinal plates of ray smooth and bare surrounded by series of skin-covered squamules. *Pholidaster.*

CC. Carinal plates not surrounded by series of skin-covered squamules.

D. A conspicuous buttress (a specialized superambulacral plate) connects first two ambulacral plates with body-wall; superambulacral plates present.

E. Adradial plates present; superomarginals not overlapping carinals ..... *Myxoderma.*

EE. Adradial plates wanting; superomarginals strongly overlapping and dominating the carinals ..... *Bythiolophus.*

DD. Superambulacral plates wanting, and hence no buttresses between ambulacral plates and body-wall ..... *Zoroaster.*

Mammaster.

Perrier, 1894. Travailleur et Talisman Stell., p. 125.
Type-species: Zoroaster sigsbeci Perrier, 1880. Comp. Rend. **91**, p. 436.

This genus is still monotypic, for the allied East Indian species all differ in the character of the marginal plates at the base of the arms. Alcock (1893. Ann. Mag. Nat. Hist., ser. 6, **11**, p. 111) considers three of his eight Zoroasters congeneric with *sigsbeei*, but he failed to note this particular feature which seems of no little importance. Fisher makes no reference to it and hence it does not seem to have attracted his attention. His work has shown that Alcock's three species are Cnemidasters but he is not sure that Mammaster can be maintained as distinct from that genus. Mammaster is evidently not common as I have found no published records of its occurrence other than those in the Blake Report — one station near St. Christopher in 208 fms. and one in the Gulf of Mexico is 321 fms.; seven specimens altogether. The largest of the Blake specimens had R about 75 mm. Perrier selected a much smaller specimen (R = 49 mm.) for his description and does not refer to the large one.

Cnemidaster.

Sladen, 1889. Challenger Ast., p. 423.
Type-species: C. wyvillii Sladen, 1889. *Loc cit.* Monotypic when established.

The collections made by the Albatross in the Far East have enabled Fisher to revolutionize our knowledge of this genus, which was based on a single very immature specimen. Fisher had seven specimens at his disposal and has been able to make clear some of the growth-changes. These bring out the important fact that the Zoroasters described under the names *nudus*, *squameus*, and *zea* are all congeneric with *wyvillii*. Indeed the four species are so closely related, it is exceedingly difficult to separate them properly. The following key is the result of studying cotypes of *nudus* and *squameus*, and the descriptions and

figures of *zea* and *wyvillii* published by Alcock, Sladen, and Fisher. But as I have not seen a specimen of either of these last two forms, which Fisher intimates may be identical, I consider the number of valid species in Cnemidaster still uncertain. I think *nudus* is undoubtedly distinct from the East Indian forms but the three latter are certainly very closely allied.

Key to the species of Cnemidaster.

Spinelets of actinal surface with thin sacculation scarcely noticeable when dry, not covering the plates very closely.
Distal carinals, and often marginals, with a central spine about as long as plate ..... *wyvillii.*
Distal carinals and marginals unarmed, but often with one or more minute spinelets or elongated granules ..... *nudus.*
Spinelets of actinal surface flat, more or less squamiform, with heavy sacculation, closely covering the plates.
Intermarginal papulae present; adambulacral ridge (on each alternate plate) with three stout spinelets ..... *squameus.*
Intermarginal papulae wanting; adambulacral ridge "bearing a row of three sabre-shaped spines and deep within the furrow a slender spinelet" ..... *zea.*

Prognaster.

Perrier, 1891. Mem. Soc. Zool. France, **4**, p. 259.
Type-species: P. grimaldii Perrier, 1891. *Loc. cit.*

Perrier, in his later, fuller account (1896. Hirondelle Stell., p. 22), says very emphatically that so far as he could see the adambulacral plates all extend equally into the furrow. This is so unusual a character for an adult zoroasterid that one can but suspect that Perrier has failed to examine the adambulacral margin with sufficient care. If he is correct, the genus is easily recognizable. The only known species was taken by the Prince of Monaco, near the Azores, in 1,568 fms.

Pholidaster.

Sladen, 1889. Challenger Ast., p. 426.
Type-species: P. squamatus Sladen, 1889. *Loc cit.*

Although Sladen published a short notice of this genus in 1885, he mentioned no species and hence the name must date from 1889. He never designated a type but Fisher (1919. Bull. 100 U. S. N. M., p. 484) has done so. The two known species were taken in the East Indian region: — *squamatus* in the Philippines in 100 fms. and *distinctus* in the Banda Sea in 140 fms. The Albatross took *squamatus* at five stations in the Philippines in 108–218 fms. These are all remarkably slight depths for a member of this family.

Key to the species of Pholidaster.

Superomarginals and most of the disk-plates concealed by flat, skin-covered scales.....*squamatus.*
Superomarginals and primary disk-scales largely bare.....*distinctus.*

Myxoderma.

Fisher, 1905. Bull. U. S. Bur. Fish., **24**, p. 316, as a subgenus of Zoroaster.
Type-species: M. sacculatus Fisher, 1905. *Loc. cit.*

This small group of sea-stars occurring off the coast of the western United States and Lower California in 284–916 fms. is well-circumscribed and Fisher has wisely (1919. Ann. Mag. Nat. Hist., ser. 9, **3**, p. 392) raised it to full generic rank. In the same paper he has described a subspecies of each of the two component species but I doubt whether sufficient material has yet been secured to warrant recognition of subspecies. In any case, however, he has set forth so well the characters of these supposed subspecies in his key, that we need not discuss them here. There are certainly two valid species.

Key to the species of Myxoderma.

Spines and spinelets more or less conspicuously sacculate; big pedicellariae in ambulacral furrow or on adambulacral spines; papulae in adults 3–5 in an area on base of rays abactinally....*sacculatum.*
Spines and spinelets little or not at all sacculate; no big pedicellariae in furrow or on adambulacral spines; papulae 1 or 2 in an area on base of rays abactinally.....*platyacanthum.*

Bythiolophus.

Fisher, 1916. Proc. Biol. Soc. Wash., **29**, p. 31, 1919. Bull. 100 U. S. N. M., p. 484, pl. 135, fig. 1–1*c*, 139, fig. 1, 2.
Type-species: B. acanthinus Fisher, 1916. *Loc. cit.*

This monotypic genus is based on a single sea-star taken by the Albatross in Buton Strait, Celebes, in 559 fms. It is unquestionably a well-marked and noteworthy type. In the diagnosis as published in 1919, the presence of *subambulacral* plates is mentioned; Dr. Fisher assures me this is a slip for *superambulacral.* In the key to genera of Zoroasteridae (1919, p. 471) Bythiolophus is said to have no adradial plates and in the figures 1 and 1c, pl. 135, as well as in the explanation of the plate, the series of plates adjoining the carinals on each side is called the superomarginal. But in the diagnosis of the genus (p. 484) and in the diagnosis and description of the species (p. 485) this series is considered as adradial and the prominence of the adradial plates is emphasized. Dr. Fisher writes me that the key was prepared much later than the text and is

correct. There are no adradials. "The prominent plates immediately adjacent to the carinals and overlapping them are almost certainly the superomarginals. ....There are therefore on each side of the carinals 2 series of marginals and 5 actinolateral series. The superomarginals are alternately larger and smaller."

Zoroaster.

WYVILLE THOMSON, 1873. Depths of the Sea, p. 154.
Type-species: Z. fulgens WYVILLE THOMSON, 1873. *Loc. cit.*

Even as here restricted, this genus contains twenty-two species, and two subspecies. It is no easy matter to separate them from each other, for the specific characters are not numerous and several are very ill-defined, so that even when species look as unlike as *fulgens* and *longicaudus* it is not easy to express their differences briefly with reliable accuracy. So little is known of growth-changes in the genus, it is quite likely the key given below will prove of little use with young specimens. The condition of the adradial series of plates furnishes the most important divisional character as it usually shows relatively little growth-change, and yet in *ackleyi* at least, it is well-marked in specimens with R = 50 mm. and quite concealed when R = 100 mm. The character and degree of armature of the carinal and superomarginal plates furnish good but less reliable features, and the tuberculation and spinulation of the actinolateral plates are of some service. But the relative length of arm increases more or less considerably with age and consequently body-form and proportions are not reliable, while the armature of the adambulacral and oral plates shows relatively little diversity in the genus. Nevertheless specific lines can be drawn with more or less accuracy and the following key will help to differentiate the species. It includes the new species described below, as well as the subspecies named by Fisher.

Key to the species of Zoroaster.

A. Adradial series of plates well-developed at least on basal half of ray.
  B. Superomarginals, some or all, armed with a central spine.
    C. Most skeletal plates, except some or all adradials, with a stout central spine.
      D. Abactinal plates nearly or quite without spinelets.....*perarmatus.*
      DD. Abactinal plates well-covered with spinelets.
        E. No large pedicellaria regularly on second spine of projecting adambulacral plates.
evermanni.
        EE. A huge pedicellaria on second spine of each projecting adambulacral plate.
evermanni mordax.
    CC. Most skeletal plates without a central spine.
      D.[1] Carinal plates wider than long; superomarginal spines irregularly developed, often wanting on most of the plates.

E.[1] Armature of actinolateral plates with a central, slender spine longer than its fellows.
F. Fourth actinolateral series of plates present; superomarginal spines not much more slender than carinal spines; spinelets scarcely fleshy ..... *fulgens*.[1]
FF. Fourth actinolateral series rudimentary; superomarginal spines decidedly more slender than those on carinals; spinelets fleshier ..... *actinocles*.[2]
EE.[1] Armature of actinolateral plates with a trio of subequal spines longer than the others. *trispinosus*.
DD.[1] Carinal plates as long as wide or longer; superomarginal spines usually well-developed and often forming conspicuous series ..... *diomedeae*.
BB. Superomarginal plates unarmed.
C.[1] Carinal plates unarmed.
D.[2] Covering of skeletal plates a close capillary spinulation.
E.[2] Intraambulacral ridge (of alternate adambulacrals) with two spines, the outer with a huge pedicellaria at tip ..... *barathri*.
EE.[2] Intraambulacral ridge with three or four spines and no huge pedicellaria .... *ackleyi* juv.
DD.[2] Covering of skeletal plates made up of fine granules, little elongated; intraambulacral ridge with one spine and no huge pedicellaria ..... *adami*.
CC.[1] Carinal plates armed with a more or less conspicuous central spine.
D.[3] Actinolateral plates with a conspicuous central spine-bearing tubercle.
E.[3] Each adambulacral plate with two bunches of pedicellariae high up in furrow .... *alfredi*.
EE.[3] No such bunches of pedicellariae.
F.[1] Rays strongly carinate; innermost adambulacral spine with a terminal tuft of about ten pedicellariae ..... *ophiactis*.
FF.[1] Rays not strongly carinate; innermost adambulacral spine with four to eight pedicellariae near tip.
G. Disk-plates unarmed; rays very long, slightly swollen at base and then tapering steadily to a slender tip; R = 18–20 r ..... *magnificus*.
GG. Primary plates of disk armed with a central spine.
H. Disk and arm-bases more or less depressed; non-projecting adambulacral plates with only two spines ..... *planus*.
HH. Disk and arm-bases not depressed; non-projecting adambulacral plates with about four spines ..... *hirsutus*.
DD.[3] No conspicuous tubercle near center of actinolateral plates though one tubercle may be somewhat larger than others.
E.[4] R = 16–18r; arms slender and tapering; no huge pedicellariae on adambulacral plates. *longicaudus*.
EE.[4] R = 10–15r; arms stouter and less tapering; huge pedicellariae present on adambulacral plates ..... *spinulosus*.
AA. Adradial series of plates more or less reduced or wanting, their place often occupied by a conspicuous groove (*sulcus*) on each side of carinal series of plates.
B.[1] Disk large, low, very distinctly delimited from rays by a ring of massive, semiglobular plates; primary plates all massive and semiglobular; all plates covered with capillary spinelets with a few coarser spinelets interspersed ..... *gilesii*.
BB.[1] Disk not as above.
C.[2] Superomarginal plates conspicuously armed with a central spine ..... *macracanthus*.
CC.[2] Superomarginal plates practically unarmed.
D.[4] Adambulacral plates with two transverse series of actinal spinelets.
E.[5] Carinal plates armed, deeply notched on both sides ..... *angulatus*.
EE.[5] Carinal plates unarmed, squarish ..... *microporus*.

[1] The figures given by Sladen (Challenger Ast., pl. 66) purporting to be *fulgens* are almost certainly *diomedeae*, for Sladen called all the western Atlantic specimens *fulgens;* his description too seems to have been made from the American form. This unfortunate state of affairs is misleading and may be why Koehler considered his Bay of Biscay specimen a new species (*trispinosus*) instead of referring them to *fulgens*. The differences between *trispinosus* and Sladen's *fulgens* are evident, but comparison of Koehler's descriptions and figures with a true *fulgens* leads one to suspect they are identical.

[2] As Fisher's description is brief and comparative, I am not sure that my summary of the distinguishing features will prove reliable.

DD.[4] Adambulacral plates with only one transverse series of actinal spines.
E.[6] Abactinal surface with coarse spinulation and numerous big pedicellariae....*ophiurus.*
EE.[6] Abactinal surface with fine spinulation and few inconspicuous pedicellariae.
F.[2] Carinal plates at base of arm quadrilateral much wider than long; superomarginals similar but smaller.....*ackleyi* adult.
FF.[2] Carinal plates about as long as wide with lateral margins more or less deeply notched; superomarginals irregularly diamond-shaped with rounded angles, not much wider than long.
G.[1] Adambulacral furrows with few pedicellariae.....*carinatus.*
GG.[1] Adambulacral furrows with many pedicellariae.....*carinatus philippinensis.*

Zoroaster perarmatus,[1] sp. nov.

Plate 4, fig. 2.

R = 98 or 125 mm.; r = 13 or 18 mm.; R = 7–7.5 r. Disk moderately large, not elevated above nor distinctly set off from rays. Primary plates distinguishable but not conspicuous and not at all swollen. Rays rather stout, the height at base equalling or exceeding the width, which is about .15–.17 of the length; rays tapering to a blunt tip, more slender in the larger specimen than in the smaller. Carinals moderate, wider than long, lateral margins narrowed by large papular areas. Adradial plates moderately well-developed, at least on basal part of arm, much longer than wide and nearly quadrilateral. Superomarginals similar to carinals but only about half as large. Inferomarginals similar but somewhat smaller and relatively longer. Actinolaterals in four series (on basal part of arm), nearly square and closely joined, the papular pores being very small. There is no indication of imbrication among either the marginal or actinolateral plates. Madreporite 2–3 mm. across, rather prominent, close to disk-margin, surrounded by five or six spinelets.

The great majority of the skeletal plates are more or less elevated at or near the middle into a conspicuous spine-bearing tubercle; the spine on the disk-plates, carinals, marginals, and adradials being stout and erect, .75–2 mm. high and .30–.90 mm. thick at base; on the actinolaterals the spine is often wanting but when present reaches a length of 5 mm. and a thickness of 1 mm. at base; in the smaller specimen, the spines are all erect, standing out at right angles to the plate-surface, but in the larger specimen, the actinolateral spines are all more or less appressed to the sides of the ray. On the disk-plates, carinals, adradials, and marginals, there are *no secondary or miliary spines whatever*, but there are numerous big pedicellariae, 1–2 mm. long. Actinolateral plates well-covered with rather stout spinelets, about ten to a plate; in alcohol, these spinelets are conspicuously sacculate but when dry the saccule disappears and

[1] *perarmatus* = thoroughly armed; in reference to the extreme development of primary spines.

they appear slender and pointed. Pedicellariae also occur on the actinolateral plates but they are not so large as abactinally. In alcoholic material, the rather thick abactinal skin is everywhere elevated into little soft knobs as many as ten or twelve occurring on a single disk-plate; these completely disappear when the material is dried. Papulae abundant all over dorsal surface, clear to arm-tips; usually there is only one to an area but on disk and arm-bases three or four may be found in one area; below the inferomarginals, papulae are very few and small and none occur below the second series of actinolateral plates.

Adambulacral plates rather longer than usual in Zoroaster; in the alternate small plates, length nearly equals breadth. Each small plate has on its actinal surface in two series, three to five spinelets, the largest being on the furrow-margin; are all more or less sacculate in alcoholic material; the largest spinelet is frequently replaced by a large pedicellaria and this is particularly so in the larger specimen. Each projecting adambulacral plate has on its actinal surface in two transverse series, four or five spinelets similar to those on the smaller plates, and in addition, there are three much stouter spines on the intraambulacral ridge; of these the innermost is smallest and carries at its tip a huge pedicellaria and two or three small ones; the second spine is thick and blunt, about 2–2.5 mm. long by .50–.60 mm. thick at base; the outermost spine is similar but larger, 3–3.5 mm. long, .60–.80 mm. thick. Of other pedicellariae on the adambulacral plates or spines, there are very few or none. Oral plates short and small; each carries three or four spines, of which the innermost is shortest, stands on the outer proximal corner of plate and carries at its tip a huge pedicellaria and one or two smaller ones; the second spine is more slender and stands nearer the radial line; back of it stands the third and stoutest spine; back of the latter is the fourth spine when it is present, but it may be wanting or it may be replaced by a huge pedicellaria. Pedicellariae of varied size may occur on the sides and at the inner end of the oral plates and in the larger specimen they are quite abundant.

Color in alcohol yellow-brown, but this fades out on drying into a dirty whitish, with papular areas darker and papulae almost black.

Station 4653. West of Peru about 17 miles, 5° 37′ S., 81° 24′ W., 536 fms. Bott. temp. 41.3°. Dk. br. gy. shore m.

Two specimens.

The general appearance of these two specimens is at first glance quite unlike but when they are carefully compared they are found to be remarkably

similar. The difference in appearance is due to the more erect position of the spines in the smaller specimen and to the greater abundance of pedicellariae in the larger. The latter also has much more tapering arms.

The species is one of the best characterized in the genus for the development of primary spines on so many abactinal plates, accompanied as it is by the total absence of small spines, gives a very easily recognized facies. There is little doubt that *perarmatus* is more closely allied to *fulgens* and *diomedeae* than is any other one of the eastern Pacific Zoroasters.

Zoroaster magnificus.

Ludwig, 1905. Mem. M. C. Z., **32**, p. 159.

There is a fine large Zoroaster in the present collection, R = 270 mm., r = 15 mm., which has been labeled by Ludwig as *Z. magnificus*. It answers well to the description except in one particular; the spinelets covering the body are thick and blunt and even when dry are not in the least "sabelförmig" as they are described in *magnificus*. If this difference is anything more than of degree, it might be of considerable importance but as I have no available specimen of *magnificus* for comparison, I attribute it to individual diversity merely.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

Asteriidae.

Heliaster cumingii.

Asterias (*Heliaster*) *cumingii* Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 180.
Heliaster cumingii Dujardin and Hupé, 1862. Hist. Nat. Zoöph. Ech., p. 343.

These two specimens, measuring about 200 mm. across, were taken in January, 1905, at Chatham Island, Galapagos, a locality from which the species has long been known. One has thirty-six and the other thirty-eight rays.

Heliaster multiradiatus.

Asterias (*Heliaster*) *multiradiata* Gray, 1840. Ann. Mag. Nat. Hist., **6**, p. 180.
Heliaster multiradiatus Dujardin and Hupé, 1862. Hist. Nat. Zoöph. Ech., p. 343.

There are two specimens of this species, taken with the preceding. One has R = 65–70 mm. and the other has R = 75–80 mm. Each has twenty-six rays, nearly the maximum number for the species.

Stylasterias paschae,[1] sp. nov.

Plate **4**, fig. 3.

Rays *nine*. R = 100 mm.; r = 10 mm.; R = 10 r. Br. = about 10 mm. Disk small, flat, covered with a rather heavy skeleton, the plates of which are much more closely united around the margin than near the center. Rays tapering but little, quite flat, with wide ambulacral grooves. Abactinal skeleton of ray made up of a carinal series of plates, a dorsolateral series on each side and the superomarginal series. Actinal skeleton composed only of large, inferomarginals and adambulacrals; there are no actinolateral plates present. Carinal plates longer than wide, abruptly wider distally than proximally; the narrow proximal end overlaps the wide distal end of the next proximal plate; every other plate is swollen near center or towards proximal end to support a large spine-bearing tubercle. Dorsolateral plates somewhat smaller than carinals, but like them in that every other one bears a spine-carrying tubercle; these plates seem to be placed obliquely, the outer end, which overlaps the upper side of a superomarginal, being more distal than the inner end. Superomarginal plates roughly cruciform with rounded ends, much wider than long; the lowest end overlaps the upper side of an inferomarginal; every other plate has a large spine-bearing tubercle while each of the alternate plates carries a single large pedicellaria. It seems probable that in life the spine-bearing carinals and superomarginals are about opposite each other, while the spine-bearing dorsolateral plates alternate with them. This arrangement is not evident however, in the present, dry specimen. Each of the dorsal spine-bearing plates, both on disk and on arms, carries a stout bluntly pointed spine, 2–3 mm. long and .50–.70 mm. thick at base. Each spine is surrounded at or near its base by a wreath of minute pedicellariae. Besides these forcipulate pedicellariae and the large forficulate ones on alternate superomarginals, forficulate pedicellariae of diverse sizes, but none either very large or very small, are scattered irregularly about all over the dorsal surface. Papular areas rather large, those near the base of each arm with six or even more papulae. Madreporite small, surrounded by six large spines, placed near disk-margin.

Inferomarginal plates smaller than superomarginals; each plate bears an oblique ridge the lower end of which is more distal than the upper; on this ridge is a series of three spines (sometimes only two) of which the uppermost is a trifle the longest and least chisel-shaped at tip, while the lowest is a trifle the shortest

[1] *Pascha* = Easter; obviously in reference to the type-locality.

and most chisel-shaped; the middle spine is a trifle the widest and heaviest; besides the spines, many inferomarginal plates carry a huge forficiform pedicellaria, 1.5 mm. long and 1 mm. wide at base; the uppermost inferomarginal spine often carries a cluster of forcipiform pedicellariae on its upper side near the middle or more distally.

Adambulacral plates short and crowded; each carries a pair of subequal, flattened, narrow, chisel-shaped spines about 2.5 mm. long; many plates carry also a huge forficiform pedicellaria, 1.5 mm. long by 1 mm. wide, placed on the inner distal angle of the plate and hence more or less within the ambulacral furrow; there are also a few very small forficiform pedicellariae scattered along the sides of the furrow. Oral plates small, each with two large spines; one at inner end of plate is about 3 mm. long and over a millimeter wide at its flattened base; the other is on the surface of the plate near its outer end and is distinctly longer and narrower. Tube-feet distinctly quadriserial, rather slender, not very crowded.

Color, light brownish yellow (dried) with the spines and pedicellariae nearly white.

Easter Island; shore. December 21, 1904.

One specimen.

This is one of the most interesting starfishes brought home by the Albatross, not only because of the distinctive combination of characters which it shows, but because of its locality. It is noteworthy indeed to find on the shores of so isolated an island a well-marked member of a genus whose nearest species is thousands of miles away. Yet there is no doubt that this Easter Island starfish is a typical Stylasterias, save for the large number of rays; the other members of the genus all belong to the northern hemisphere, only one occurring as far south as the equator. The number of rays, the presence of three inferomarginal spines and the character and distribution of the pedicellariae serve to distinguish *paschae* from any other Stylasterias. Verrill suggested the group only as a subgenus of Orthasterias but it seems to be well-circumscribed and is a convenient group to use, once the disintegration of Asterias is permitted to set in.

Brisingidae.

Fisher's (1917. Ann. Mag. Nat. Hist., ser. 8, **20**, p. 418–431) recent thoroughgoing revision of this family, in which he recognizes fifteen genera, makes it possible as never before to appreciate the diversity it shows. It also reveals

how many notable forms are recent discoveries, and emphasizes the fact that we are as yet far from realizing the entire content of the family. This idea is still further emphasized by the present collection, for while there are only eight disks and some scattered arms from but five stations, no fewer than five species are represented and four of these are new to science.[1] The one previously described species moreover has hitherto been known only from the eastern tropical Atlantic, where it was taken by the CHALLENGER! Three of the five species were taken at a single station. These facts all go to show how very incomplete our knowledge of this remarkable deep-sea family still is. Of very few species has sufficient material been secured to permit real knowledge of the specific characters, and there is not a single form of which the growth-changes and the limits of individual diversity are known. Under such circumstances the addition of new species based on single and more or less fragmentary specimens is not very desirable, but on the other hand material so rare and so difficult to secure must not be ignored. The following notes may be of service in elucidating generic and specific limits within the family.

Brisingella monacantha,[2] sp. nov.

Plate **5**, fig. 3, 4.

Disk and number of rays unknown. Rays about 200 mm. long, 4 mm. wide at base, 5.5 mm. wide at middle of genital area and 2.75 mm. wide one hundred millimeters from base. Genital area begins 10 mm. from proximal end of ray and extends about 25 mm.; it is covered by delicate naked gray skin and is crossed by eleven or twelve calcareous ridges ("primary costae" of Fisher); there are three or four additional costae distal to the swollen area and indications of four or five more proximal to it; there are two incomplete or secondary costae on each ray; otherwise there is no calcareous material on dorsal side of rays. Adambulacral plates about 2 mm. long on proximal half of ray, somewhat shorter distally; width at proximal end about half length, distinctly less at middle and slightly more at distal end where there is a marked projection or peak on the inner corner; at the base of this peak on the actinal surface of plate but close to the adambulacral margin is a distinct spine-bearing tubercle; on proximal part of arm, there is a fairly close approximation between costae and

[1] It is interesting to note that all of the specimens were taken in water more than 2,200 fms. deep and at a temperature lower than 36° F.

[2] *monacanthus* = having a single thorn or spine, in reference to the armature of the adambulacral plates.

adambulacral plates. Inferomarginal plates very small and difficult to detect; apparently only every alternate plate carries a spine but proximally this alternation is not perfect as there two successive plates may be spine-bearing. Adambulacral armature consisting of a single spine; on no plate is there any indication of a furrow-spine or of a point to which it might have been attached. Both inferomarginal and adambulacral spines are for the most part missing or when present are broken, but to judge from the fragments distally the inferomarginals were the larger and both series were encased is thick skin. Inferomarginal tubercles are placed directly above adambulacral tubercles but only adjoining every other adambulacral plate. Tube-feet of moderate size arranged in pairs opposite the distal half of the adambulacral plates; pores about one millimeter in diameter. Genital glands moderately developed, one on each side of swollen area.

Station 4651. Peru: west of Aguja Point, 111 miles, 2,222 fms. Bott. temp. 35.4°. Fne. stky. gy. m.

Two rays.

Comparison of these rays with Fisher's figures and description of *Brisinga fragilis* (1906. Bull. U. S. Fish Comm., p. 1115, plate 46, fig. 1, plate 48, fig. 3, 3a–c), the genotype of Brisingella, has left no doubt in my mind that they too represent a species of this genus, and one which is apparently unique in its adambulacral armature. As the uniform absence of a furrow-spine at either end of the adambulacral plate and the equally uniform occurrence of only a single actinal spine on the same plates and that aboral, make the recognition of the species easy, it seems proper to give it a name.

Freyellidea brevispina,[1] sp. nov.

Plate **5**, fig. 1, 2.

Rays 11. Disk 12 mm. across. R = 165 mm. or more. R = about 14d. Disk circular with nearly vertical sides between the rays, densely beset with spinelets, .50–.75 mm. long; these spinelets are slender, slightly thickened at tip where they terminate in two, three, or four short points; occasionally the tip is blunt; the plates bearing these spinelets are difficult to make out but apparently there is only one spinelet to a plate; pedicellariae of diverse but small size occur not rarely among the spinelets. Madreporite small but elevated and prominent on the margin of disk. Rays slender, only a little over 2 mm. wide

[1] *brevispinus* = having short spines, in reference to the unusual oral spines.

at base and with a maximum width, about 12 mm. from base, of only 4 mm.; genital area very short only about one tenth of ray-length, covered closely by plates, spinelets, and pedicellariae like those of disk but notably smaller; beyond genital area, minute pedicellariae continue for a few joints only on the dorsal surface; along sides of ray however, they continue more or less abundantly, and distally they again invade the dorsal surface, so that the tips of the rays are apparently enclosed in skin densely covered with these very minute pedicellariae.

Adambulacral plates long and narrow, about 2 mm. by .75, so little concave on the furrow-side that they are almost cylindrical; there is a moderately developed peak at the inner, distal corner; their armature consists of two spinelets, one of these is placed on the inner peak of the plate and extends diagonally across the furrow, while the other is near the center of the plate, or a little distal to it, on the actinal surface; the furrow-spine is short and thick, not much longer than width of furrow, and bears a number (5–8) of small pedicellariae; the actinal spine is very slender, only about 3 mm. long at base of arm but becoming 5 mm. long on distal part of ray; it is very acicular but is clothed in loose skin, densely covered with very minute pedicellariae and unless this skin is damaged, the slenderness of the spine is not apparent. Above every other actinal spine is an inferomarginal spine which at base of arm is only 4 mm. long but reaches a maximum length of at least 7 mm. distally; the actinal spines overlaid by the inferomarginals are always noticeably smaller than those which are unaccompanied, but the latter are not so large as the inferomarginals; like the actinal spines, the inferomarginals are clothed in thick, pedicellaria-covered skin. Tube-feet moderate, in pairs opposite distal part of adambulacrals; pores about 1 mm. across. Oral plates short, moderately high at distal end with a keel along midradial line; each plate carries near distal end a long, slender skin covered spine, about 5 mm. long, distinctly thickened at tip; at distal outer corner a small, pedicellariae-bearing spinelet like that of the adambulacral plates; and at inner end, two, or rarely three, short, more or less curved, flattened, wide spinelets, much wider at tip than at base; some are so wide at tip as to be almost fan-shaped; inner is much smaller than outer; the latter may be over a millimeter long and nearly a millimeter wide at tip; these inner oral spines are not skin-covered and carry no pedicellariae. Color, in alcohol, nearly white.

Station 4740. Eastern Tropical Pacific, 9° 2′ S., 123° 20′ W., 2,422 fms. Bott. temp. 34.2°. Dk. gy. glob. and rad. oz.

One specimen.

Examination of the rays shows that there is no evidence of a syzygy at the base; all of them are still attached to the disk, though broken at a greater or less distance from it. The arrangement of marginal, adambulacral, and oral plates about the mouth seems to be like that of *Freyellidea microplax*, the genotype. There is a single genital gland on each side of the swollen area at base of ray. The combination of characters which serves to separate this species from all those previously known lies in the very long, slender arms, the unusually short inferomarginal and adambulacral spines, and the extraordinary oral spinelets.

Freyellidea octoradiata,[1] sp. nov.

Plate 6, fig. 1, 2.

Rays 8. Disk 16 mm. across. Rays about 185 mm. long or perhaps more (the tips are missing). R = about 12d. Disk high and slightly tumid, closely covered with thick overlapping plates, a millimeter across, more or less; in each interradius, the large interradial plate is conspicuous, occupying the whole side of the disk in those areas; interradial plates smooth and bare, but all other disk-plates with several (usually three or four) small, slender spines and rarely one or two pedicellariae; the latter are nearly always on plates near arm-bases; spinelets about .50 mm. long, with blunt and often slightly swollen tips. Rays rather stout, about 5.5 mm. wide at base and 3 mm. wide near middle; genital area about 35 mm. long and 8 mm. wide, where widest. Basal fourth of ray more or less covered with spiniferous plates, similar to those of the disk but larger and carrying more spinelets and pedicellariae; as far out as the genital area extends, these plates are close together and cover the region completely but beyond that point they become more and more separated, fewer in number and smaller in size, until they finally disappear as very minute fragments carrying a single pedicellaria; on the genital area the plates are, as a rule, much wider than long, and the largest exceed 2 mm. in breadth; near tip, pedicellariae-covered skin clothes dorsal and lateral parts of ray.

Adambulacral plates rather short and stout, nearly cylindrical; thickness more than half length; inner, aboral peak present but slender; armature as usual in the genus; a short spinelet on the peak, extending across furrow and carrying small pedicellariae; and a large actinal spinelet, the tubercle of which occupies a large part of distal half of plate; near base of arm, these actinal spinelets are very stout with enormously widened flat, dentate tips, as in *F. insignis*

[1] *octoradiatus* = having eight rays, in reference to the unusually small number of arms.

but heavier than in that species; beyond genital area, they rapidly assume an ordinary blunt tip; where longest they are about 5 mm. long and decrease in length and stoutness distally. Inferomarginal spines at first rather small, not equalling the actinal adambulacral spines, but distally they gradually come to exceed them; as usual there are two actinal spines to one inferomarginal, the latter overlying one of the former. Both actinal and inferomarginal spines are more or less completely encased in pedicellariae-covered skin. Tube-feet very large, the pore occupying nearly the whole area bordered by the adambulacral plate. Oral plates small, with no midradial keel; at distal outer corner is a small spinelet similar in position and appearance to the adambulacral furrow-spine, while on the adoral margin are two similar but longer spines which widely diverge from each other; at the center of the actinal surface of the plate is a long spine, like the adambulacral actinal spines, with a conspicuously flat dentate tip; all the oral spines carry numerous pedicellariae. Color, in alcohol, light buff.

Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4740. Eastern Tropical Pacific, 9° 2′ S., 123° 20′ W., 2,422 fms. Bott. temp. 34.2°. Dk. gy. glob. and rad. oz.
Station 4742. Eastern Tropical Pacific, 0° 3′ 29″ N., 117° 15′ 48″ W., 2,320 fms. Bott. temp. 34.3°. Fne. lt. gy. glob. oz.

Three specimens.

Two of these specimens are of nearly equal size but the one from St. 4740 is very much younger. The disk is only 7 mm. across; two of the arms are broken near the disk, the others near their tips or beyond the genital area, which is little enlarged. None of the adambulacral actinal spines show very much expanded tips but they are relatively short and in view of the number of rays, I consider this specimen *octoradiata*.

The small number of rays, apparently quite constant, the large feet, the short, thick adambulacral plates, and the relatively short actinal and inferomarginal spines combine to give this species a very characteristic facies. The disk too is relatively small and the rather stout arms are longer than usual. The generic characters are well shown, as there is no syzygy at the base of the arm, the genital tufts are single on each side of the arm and the interradial angle is as in *microplax* except for the very much larger interradial plate.

Freyellidea oligobrachia,[1] sp. nov.

Plate 6, fig. 3, 4.

Rays 6. Disk 10 mm. across. Rays all broken but certainly more than 90 mm. long and probably in excess of 100. Disk moderately high but flat, covered with relatively large, thick, irregular plates which more or less overlap; the largest are about .75 mm. in diameter and carry as many as fifteen spinelets; spinelets very small with one, two, or three glassy terminal points; around anus the spinelets are noticeably coarser; there are a few small pedicellariae scattered among the spinelets. Rays rather stout, about 4 mm. wide at base, and 3 mm. near middle; genital area not sharply defined, about 20 mm. long and only 4.5 mm. wide, where widest; its covering is very similar to that of the disk, except that spinelets are fewer and pedicellariae much more numerous; beyond genital area, the plates disappear quite rapidly.

Adambulacral plates long and slender, the distal end curved inward slightly, its inner corner prolonged into a long slender peak; armature, of a single spine about 3 mm. long, which is located on aboral end of plate on actinal surface, and is normally covered with thick skin, densely clothed with pedicellariae; at base of ray these spines have flat, expanded, dentate tips but these rapidly give way to simple points and distally the spines are very acicular; there is no furrow-spine and no pedicellariae in the furrow. Inferomarginal spines small, acicular, completely skin covered like the actinal spines, which they seldom equal in length and never exceed; basally they occur at irregular intervals of 2–4 adambulacral plates but distally they are more regular and seem to accompany every other actinal spine. Tube-feet rather small, lying against the distal curved end of adambulacrals. Oral plates small, squarish, little swollen; on actinal surface at distal end is a long, clavate spine covered with skin and numerous pedicellariae; at adoral outer corner of plate are two or three slender spinelets lying horizontally and each carrying a few pedicellariae. There is no spinelet at distal outer corner of plate but there are a few pedicellariae in the furrow at that point. Color, in alcohol, nearly white.

Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.
Station 4742. Eastern Tropical Pacific, 0° 3′ 24″ N., 117° 15′ 48″ W., 2,320 fms. Bott. temp. 34.3°. Fne. lt. gy. glob. oz.

Three specimens.

[1] ὀλίγος = few + βραχίων = arm, in reference to the number of rays, the minimum for the genus.

The specimen described is the largest and is from St. 4742. The one from St. 4656 is smaller, with disk only 6 mm. across; in all particulars however, it agrees with the holotype. The third specimen is from St. 4742 and measures only 4 mm. across the disk; it is surprisingly like the holotype and offers no features worthy of special comment. The generic characters are well shown by the holotype, in which the base of each ray contains a well-developed genital tuft on each side. The junction of the oral plates with the interradial is very clear in the specimen from St. 4656. The rays of all the specimens are still attached to the disk, though several are broken off near the base. The presence of six rays and the absence of a furrow-spine ally this species with the following, but the general facies is quite different. They evidently form a very distinct section of the genus.

Freyellidea tuberculata.

Freyella tuberculata SLADEN, 1889. Challenger Ast., p. 638.
Freyellidea tuberculata FISHER, 1917. Ann. Mag. Nat. Hist., ser. 8, **20**, p. 429.

The specimen at hand is of just the same size as the one described by Sladen, having the disk 12 mm. across and the rays 240 mm. long. It answers to the description in practically every particular and I have sought in vain for some character by which the Pacific form might be separated from the Atlantic. There is then in the discovery of this species in the Pacific by the ALBATROSS further evidence in support of the view that the true deep-sea fauna is essentially cosmopolitan.

Station 4742. Eastern Tropical Pacific, 0° 3′ 24″ N., 117° 15′ 48″ W., 2,320 fms. Bott. temp. 34.3°. Fne. lt. gy. glob. oz.

One specimen and three additional arms.

EXPLANATION OF THE PLATES.

PLATE 1.

PLATE 1.

Thoracaster magnus Ludwig. Cotype from Station 4717. Nat. size.

1. Upper surface.
2. Lower surface.

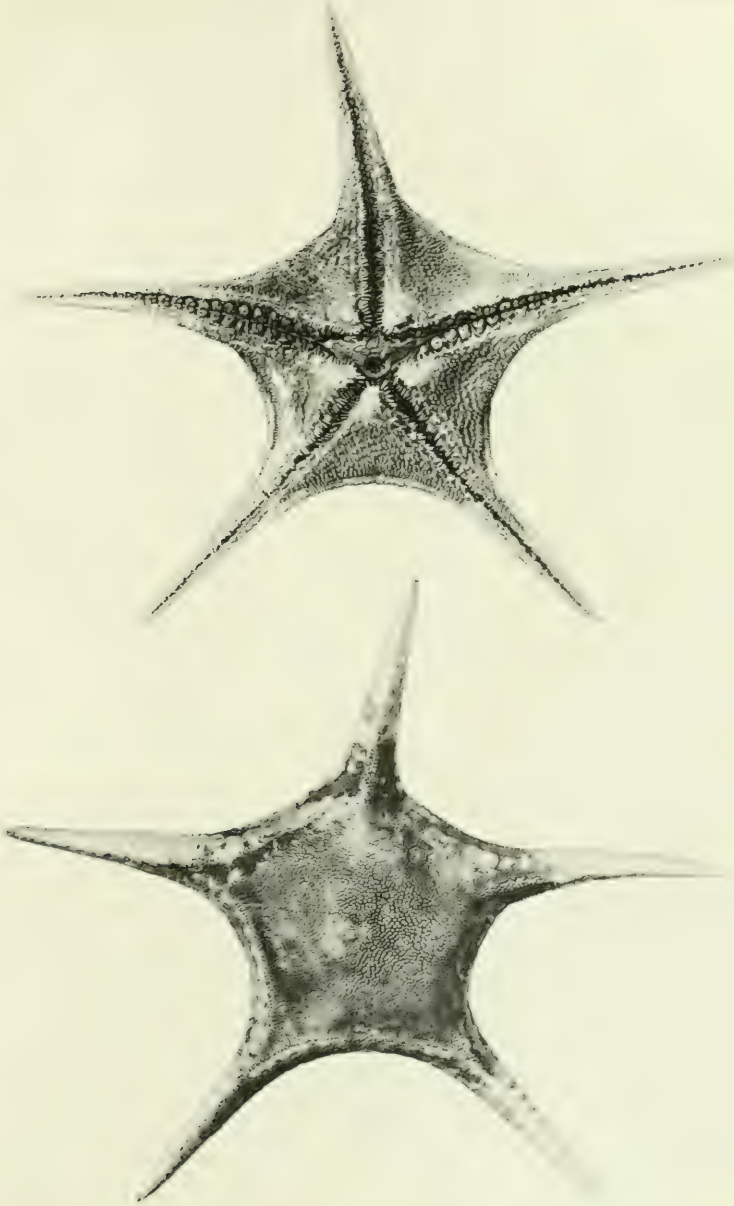


PLATE 2.

PLATE 2.

Styracaster monacanthus Ludwig. Holotype from Station 4701. × 2.

1. Upper surface.
2. Lower surface.

Styracaster paucispinus Ludwig. Cotype from Station 4658. × 2.

3. Upper surface.
4. Lower surface.

Albatrossia nuda (Ludwig). Holotype from Station 4647. × 4.

5. Upper surface.
6. Lower surface.

Eremicaster vicinus (Ludwig). Cotype from Station 4670. × 2.

7. Upper surface.
8. Lower surface.

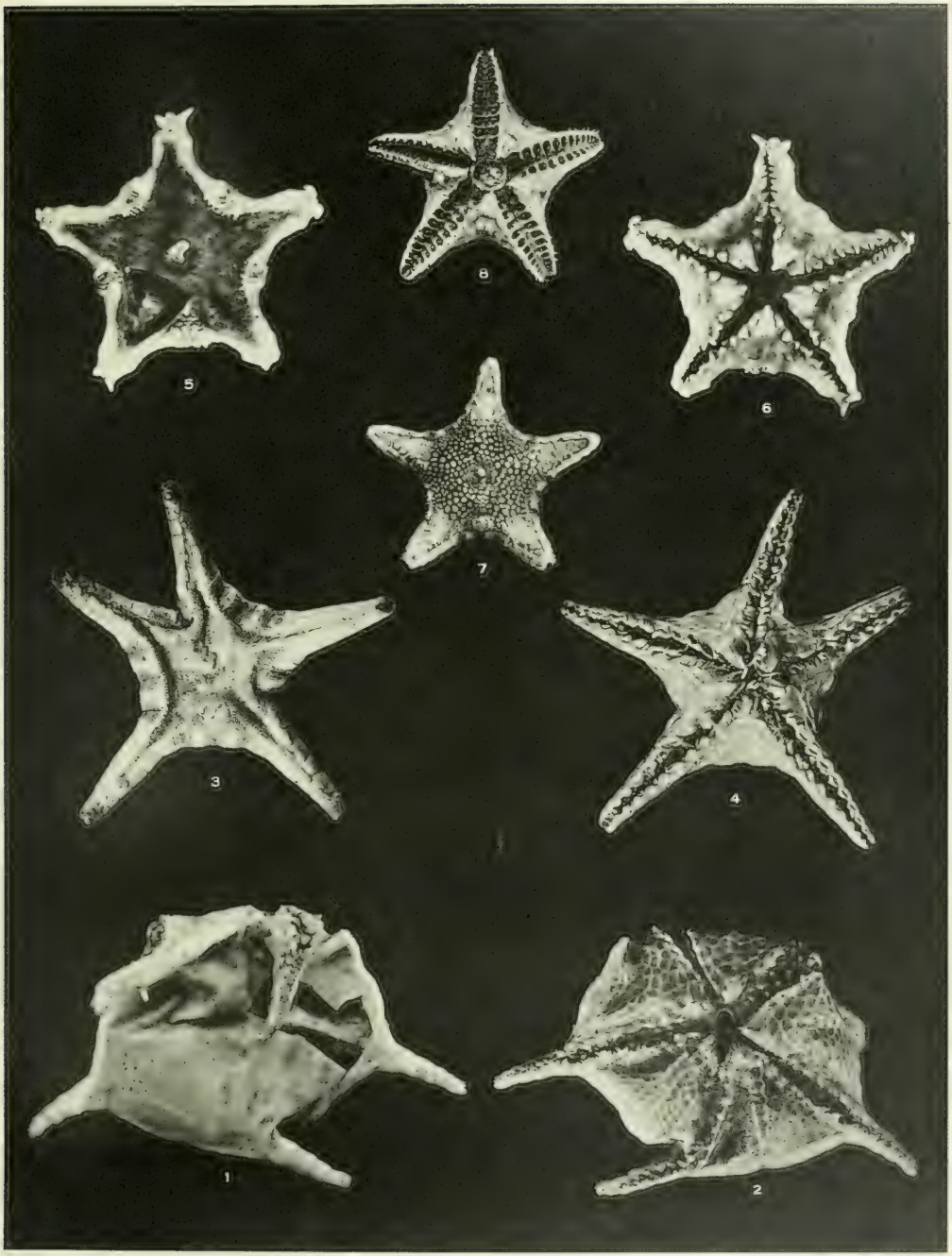

8
5
6
7
3
4
1
2

PLATE 3.

PLATE 3.

Hymenaster trias H. L. Clark. Holotype from Station 4672. × 2.

1. Upper surface.
2. Lower surface.

Litonotaster tumidus H. L. Clark. Paratypes from Station 4672. × 2.

3. Upper surface of a long-rayed specimen.
4. Lower surface of same.
5. Upper surface of a short-rayed specimen.
6. Lower surface of same.

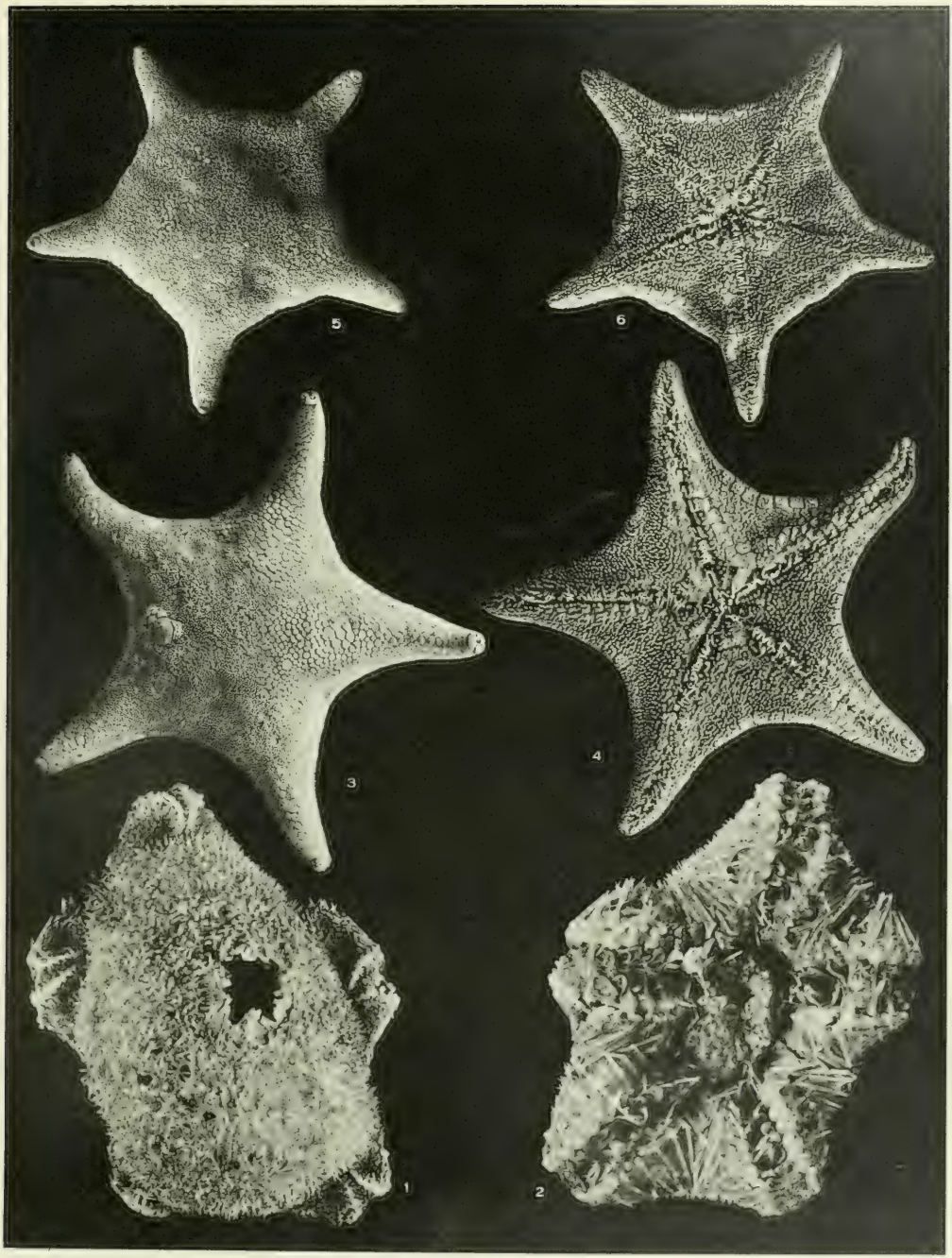

5
6
3
4
1
2

PLATE 4.

PLATE 4.

Hymenaster cremnodes H. L. Clark. Holotype from Station 4658.

1. Seen from the side. × 2.

Zoroaster perarmatus H. L. Clark. Holotype from Station 4653.

2. Upper surface. Nat. size.

Stylasterias paschae H. L. Clark. Holotype from Easter Island.

3. Upper surface. Nat. size.

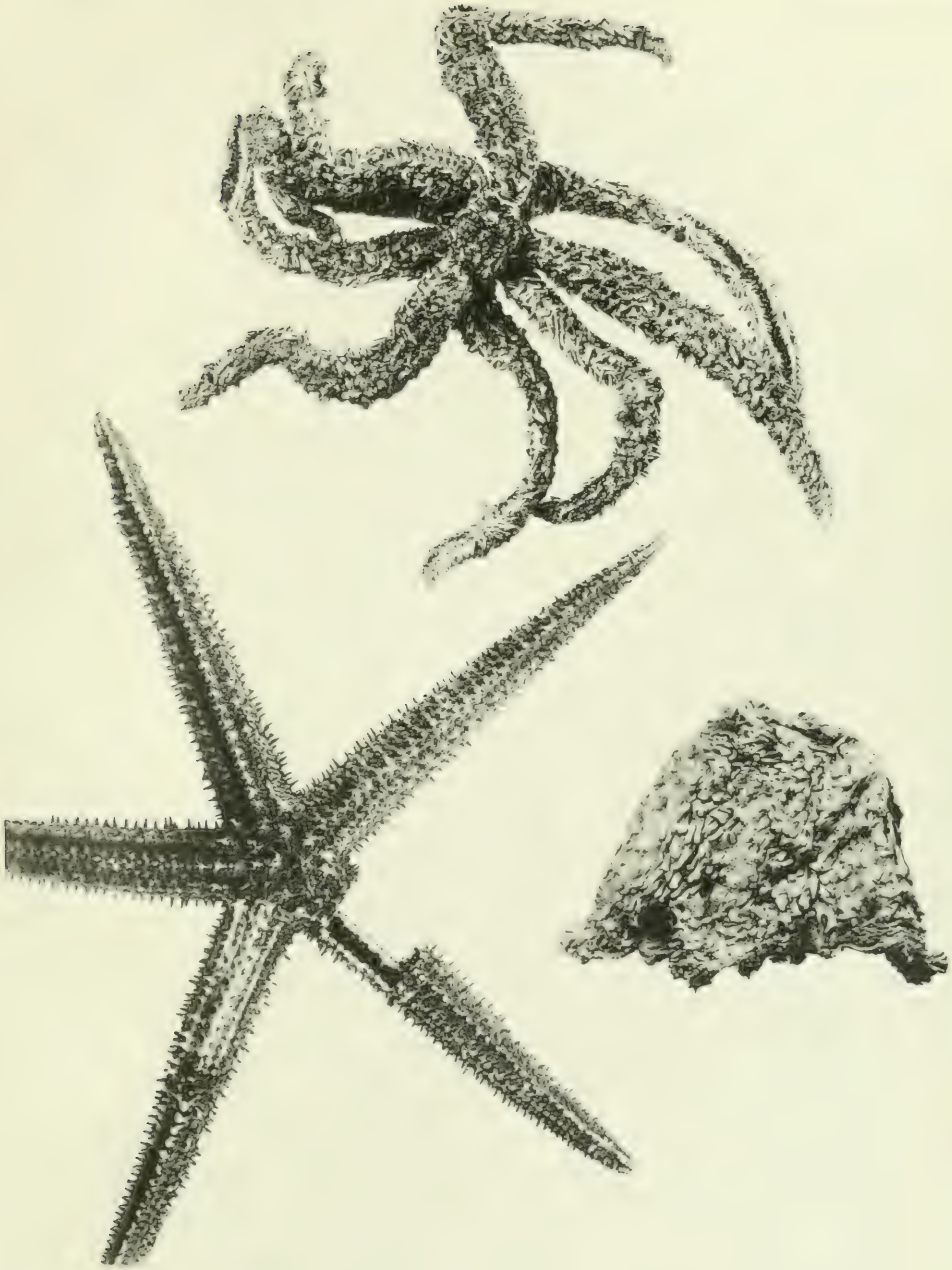


PLATE 5.

PLATE 5.

Freyellidea brevispina H. L. Clark. Holotype from Station 4740. × 3.

1. Upper surface.
2. Lower surface.

Brisingella monacantha H. L. Clark. Part of ray of paratype from Station 4651. × 3.

3. Lower surface.
4. Side view.

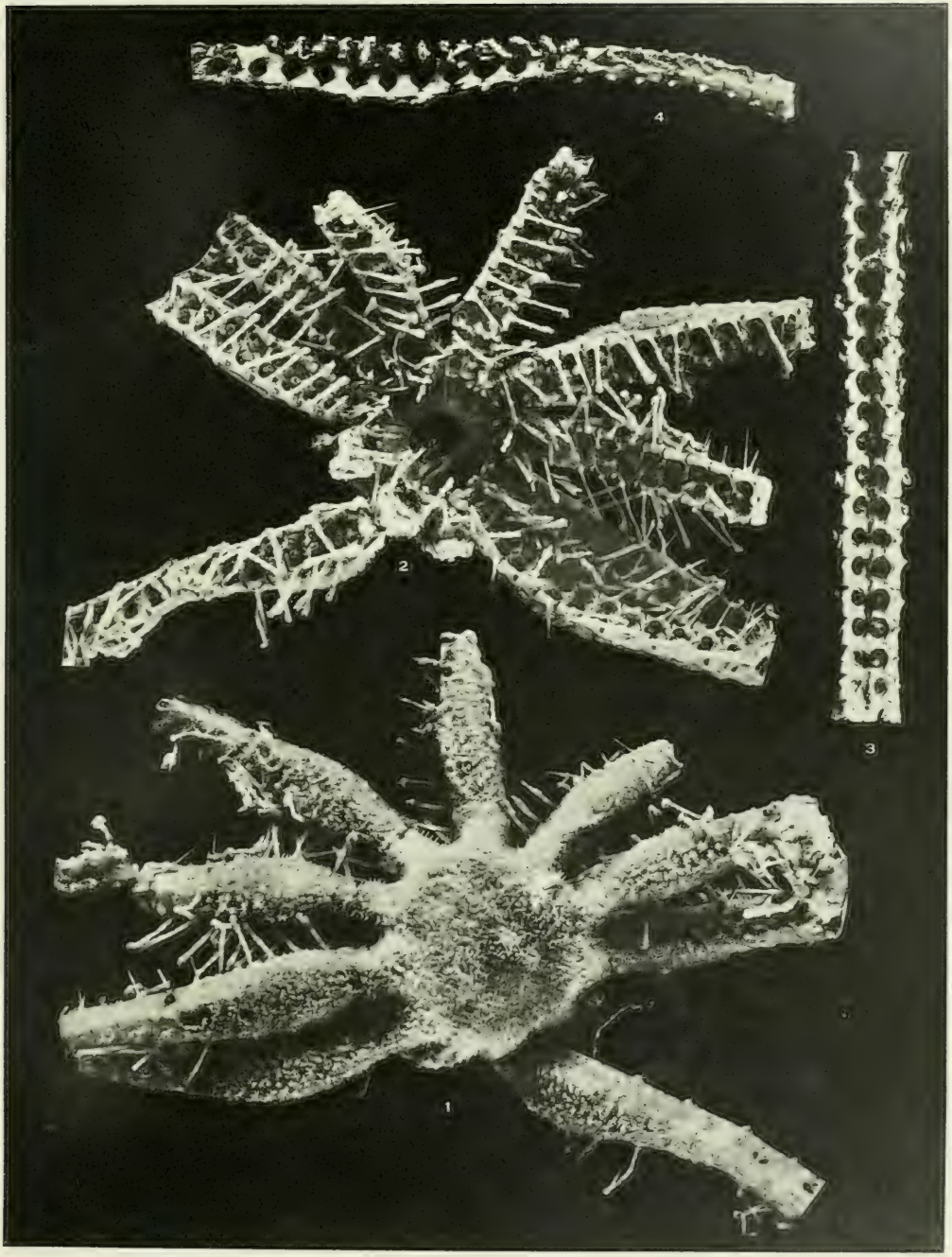

4
2
3
1

PLATE 6.

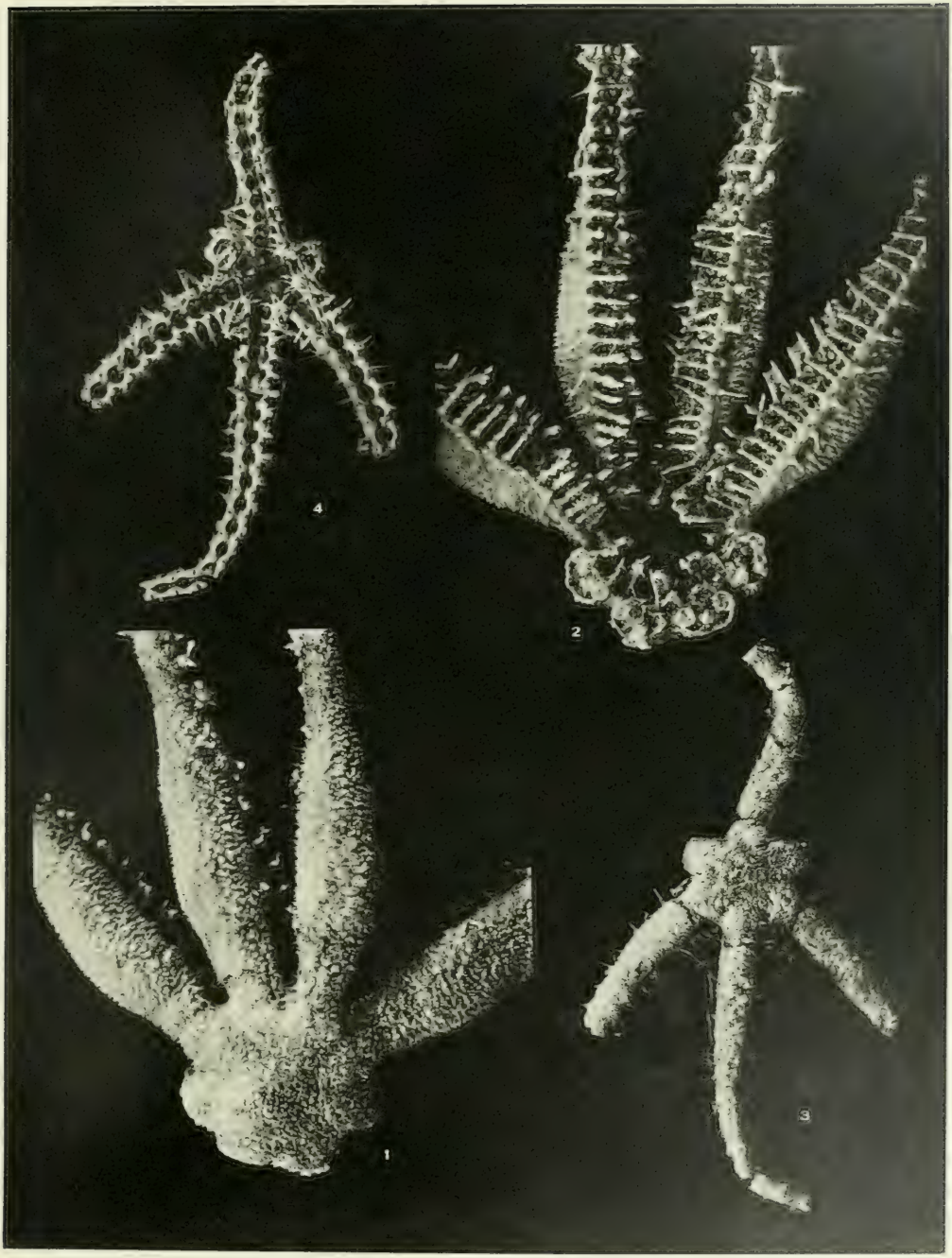
PLATE 6.

Freyellidea octoradiata H. L. Clark. Holotype from Station 4742. × 2.

1. Upper surface.
2. Lower surface.

Freyellidea oligobrachia H. L. Clark. Paratype from Station 4656. × 3.

3. Upper surface.
4. Lower surface.


4
2
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3

Memoirs of the Museum of Comparative Zoölogy
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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, TO MARCH, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

XXII.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS" FROM OCTOBER, 1904, TO MARCH, 1905, LIEUT. COMMANDER L. M. GARRETT, U. S. N., COMMANDING.

XXXIII.

HOLOTHURIOIDEA.

By HUBERT LYMAN CLARK.

WITH FOUR PLATES.

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EXPLANATION OF THE PLATES

TROPICAL PACIFIC HOLOTHURIOIDEA.

INTRODUCTION

The number of holothurians collected by the Albatross on her Tropical Pacific expeditions was not large and hence a single report is preferable. Those taken in 1899–1900 were originally sent to Professor Mitsukuri at Tokyo and he had made numerous notes, prepared many slides, and identified many of the species before his failing health put an end to his work. Later the collection was received at Cambridge. The collections of 1904–1905 were sent to Professor Ludwig at Bonn but his death occurred before he had made any identifications and the material was forwarded to Cambridge in the spring of 1914.

The earlier collection is a small one, consisting of only fifty-nine specimens, representing sixteen species, and eleven are common, wide-spread Indo-Pacific littoral forms. Of the remaining five, two appear to be species hitherto unknown.

Expedition 1899–1900 — List of Species — (New Species indicated by an *).

Synapta maculata.
Pseudocucumis africana.
Pelagothuria natatrix.
*Peniagone bispiculata.
Peniagone vitrea.
Euphronides verrucosa.
*Mesothuria multipora.
Stichopus chloronotus.
Holothuria atra.
Holothuria difficilis.
Holothuria impatiens.
Holothuria leucospilota.
Holothuria monocaria.
Holothuria pardalis.
Holothuria scabra.
Actinopyga mauritiana.

The collection of 1904–1905 is a much larger and more interesting one, containing 218 specimens of forty-three species, of which eleven are described as new and only a dozen are well-known littoral forms. There are also half a dozen additional specimens, which owing to their condition are quite unidentifiable; they seem to represent three species of Elpidiidae; one is probably referable to Euphronides while the others are apparently Psychropotes.

Expedition 1904–1905 — List of Species — (New Species indicated by an *).

Protankyra abyssicola.
*Chiridota aponocrita.
Chiridota rigida.
*Myriotrochus bathybius.
*Myriotrochus giganteus.
*Molpadia bathybia.
Molpadia holothurioides.
Ceraplectana trachyderma.
Cucumaria abyssorum.
Echinocucumis bitentaculata.
Pelagothuria natatrix.
*Parelpidia anamesa.
Scotoplanes murrayi.
*Periamma tetramerum.
Peniagone intermedia.
Peniagone setosa.
Oncirophanta mutabilis.
*Scotodeima parvispiculatum.
Scotodeima setigerum.
Laetmophasma fecundum.
Capheira sulcata
*Euphronides dyscrita.
Euphronides verrucosa.
Psychropotes raripes.
Benthodytes glutinosa.
*Benthodytes regularis.
Benthodytes sanguinolenta.
*Mesothuria megapoda.
Mesothuria multipes.
Synallactes aenigma.
*Synallactes triplax.
Pseudostichopus mollis.
Stichopus variegatus.
Holothuria arenicola.
Holothuria atra.
Holothuria cinerascens.
Holothuria imitans.
Holothuria impatiens.
Holothuria languens.
Holothuria lubrica.
Holothuria marenzelleri.
Actinopyga lecanora
Actinopyga parvula.

The 1904–1905 collection was always considered by Mr. Agassiz an exceptionally important one, an opinion based in part on the remarkably interesting trawl-hauls at several stations. Thus at station 4647, nine species were obtained, representing eight different genera, and two of the species are very notable new forms. At station 4649, five species of five genera were taken, one of the species being new. At 4651, seven species of seven genera, were secured and at 4656, five species of five genera. At 4658, eight species of seven genera, with two new species, were taken, and again at 4672, eight species of eight genera, with two new species, were brought in. It is not surprising therefore that Mr. Agassiz looked upon the collection as of great value. That it is not of more unusual importance, is owing to the facts that even the new forms nearly all belong to genera previously known from the eastern Pacific, while the Albatross 1891 expedition secured a large proportion of the species occurring in the deep waters of the region.

The new species described in the present report belong to the four families Synaptidae, Molpadiidae, Elpidiidae, and Holothuriidae, but the three new members of this last family are all members of the subfamily Synallactinae. The identification of deep-water holothurians, especially synallactids and elpidiids, is rendered difficult by the bad condition in which they reach the surface. It seems to be very exceptional for them to be taken in uninjured condition. More-

over the amount of their muscular contraction, and the particular form assumed, are subject to extraordinary diversity, as a result of which two very different specimens may prove to have the same essential structure and the same calcareous particles. In many cases the specimens are so distended with fine mud, it is hopeless to make anything out of the internal structure, and not infrequently the outer surface of the body-wall is so largely rubbed away, no pedicels are left and it is difficult to find any calcareous particles. In view of these conditions, calcareous particles prove exceptionally useful and faith in their genetic significance and taxonomic importance is greatly strengthened. It is very doubtful whether holothurians with essentially different spicules should be placed in the same genus and it is almost universally true that essential similarity in spicules indicates close relationship. At present our classification contains some very large and unnatural groups treated as genera (Cucumaria, Thyone, and Holothuria for example) which can probably be broken up into a number of small, natural genera by a proper valuation of their calcareous particles.

Of the new species described, all except the Benthodytes and the Euphronides, are particularly characterized by their spicules. The new Benthodytes is easily recognized, when well preserved by the body-form and arrangement of pedicels, and the Euphronides by the size and position of the dorsal appendage, but whether badly damaged or contracted specimens could be correctly identified is very doubtful. Of all the new forms, the two remarkable species of Myriotrochus are unquestionably the most interesting, as the genus has hitherto been considered characteristic of the subarctic zone. It is very perplexing to find the two closely allied species at one and the same station and nowhere else, for they are unquestionably quite distinct. The new Chiridota is interesting because it shows a well-marked spicule-character, unusual in this homogeneous genus. The same is true of the new Molpadia, since that is a genus in which the calcareous tables often lack any real distinctiveness.

The collections add little to our knowledge of the geographical distribution of holothurians, except in the notable extension of the range of Myriotrochus, to which reference has already been made. But it is of some interest to find *Chiridota rigida* as far southeast as Easter Island, *Benthodytes glutinosa* in the eastern Pacific and *Ceraplectana trachyderma* so far to the southward of the type-locality, the only place whence it was hitherto known.

The colored figures (Plates 1–3) were prepared by Mr. Agassiz and Mr. Westergren during the voyage of 1904–1905, but unfortunately the specimens from which they were made were not preserved separately or otherwise ade-

quately indicated, and hence in only a few cases has it been possible to determine from what specimen the colored figure was drawn. Each of the drawings, however, has the date and the number of the station at which the specimen was taken and it has therefore been possible in most cases by a process of elimination to find the probable originals. But doubts remain, and in two instances there seem to be no originals preserved. One of these figures having little that is distinctive is accordingly omitted from the published plates but the other is of such an unusual color (Plate 3, fig. 5), its publication seems desirable, especially since there is little doubt as to the genus.

SYSTEMATIC ACCOUNT.

SYNAPTIDAE.

Synapta maculata.

Holothuria maculata CHAMISSO & EYSENHARDT, 1821. De anim. Kotzebue obs., p. 352.
Synapta maculata JÄGER, 1833. De Holothuriis, p. 15.

This species was met with by the ALBATROSS twice on her earlier voyage. At Papeete, September 28, 1899, a good example of the typical form was secured and at Makemo, in the Paumotus, October 21 of the same year, two handsomely marked specimens of the variety *agassizii* (*S. agassizii* Selenka) were taken. These specimens are very conspicuously striped, five nearly white bands alternating with five more or less mottled brown ones of about the same width. Sufficient knowledge of this variety in life, and of the species as well, is as yet lacking, so that the true relation between them is unknown.

Protankyra abyssicola.

Synapta abyssicola THÉEL, 1886. CHALLENGER Hol., pt. 2, p. 14.
Protankyra abyssicola ÖSTERGREN, 1898. Öfv. K. Vet. Akad. Forh., **55**, no. 2, p. 117.

At two stations, this species was met with in 1904. Many of the specimens are of such size as to show that the species reaches a length of 150 mm. or more in life, with a corresponding diameter of at least 10 mm. In most of the specimens, the color is yellowish without red pigment but one is somewhat reddish. All have the full-sized anchors with distinct teeth on the arms, so that these specimens are certainly not *P. pacifica*. The appearance of the anchors, the developmental stages of which have perfectly smooth arms, leads one to question whether *pacifica* is really a valid form.

Station 4651. West of Peru, 5° 41′ 42″ S., 82° 59′ 42″ W., 2,222 fms. Bott. temp. 35.4°. Stky. fne. gy. s., trace of shore-mud.

Station 4666. Eastern Tropical Pacific, 11° 55′ 30″ S., 84° 20′ 18″ W., 2,600 fms. Bott. temp. 34.9°. Lt. gy. oz.

Sixteen specimens.

Chiridota aponocrita,[1] sp. nov.

Plate **4**, fig. 1, 2.

Length in life, apparently about 75 mm.; the two fragments of the holotype measure in their preserved condition, 20 × 5 mm. and 15 × 4 mm. but these seem to constitute only about half the animal. Color (preserved), creamy white. The anterior piece bears twelve tentacles, each with seven digits on a side; tentacles 2–3 mm. long; terminal digits a full millimeter. Calcareous ring narrow, with no conspicuous projections on either margin; tentacle-bases relatively large, nearly concealing calcareous ring.

Calcareous particles numerous and characteristic. In tentacles, rods few, 40–60 μ long (Plate **4**, fig. 1) very slightly branched at one or both ends, very little curved. Wheel-papillae numerous in all interambulacra anteriorly but few and scattered in ventral interambulacra at middle of body and perhaps posteriorly too; the absence of an indubitable posterior end prevents a positive decision. Wheels numerous in each papilla, and of diverse sizes, ranging from 55 to 110 μ in diameter. Body-wall everywhere, even in skin overlying wheel-papillae, crowded with minute curved rods or doughnut-shaped particles (Plate **4**, fig. 2) only 12–20 μ long. No calcareous particles in longitudinal muscles.

Panama: Perico Island.

Three fragmentary specimens.

This Chiridota, although superficially not unlike several of the smaller members of the genus, is easily distinguished by the uniform coat of miliary particles in the outer layer of the body-wall. These are so numerous and small and have such a characteristic form, that *aponocrita* is one of the most easily recognized members of the genus. It is apparently a littoral species and no doubt occurs elsewhere at Panama, than at Perico Island.

Chiridota rigida.

Semper, 1868. Holothurien, p. 18.

There are two headless specimens in the 1904–1905 collection, measuring 25–30 mm. long by 4–5 mm. in diameter, which seem to be this species, though of course they are not certainly identifiable. They are of special interest because

[1] ἄπονος = without trouble + κρίτος = picked out, in reference to the ease with which it may be distinguished from allied forms.

they were taken on the shores of Easter Island, December 20, 1904. The wheels are only 45–65 μ in diameter and the curved rods, which are very sparsely scattered and not very variable, are but 27–36 μ in length. The small species of Chiridota need a careful revision based on the size, character, and distribution of the calcareous particles and when this is made the Easter Island form may be entitled to rank as a separate species, as the wheels seem to be much smaller than in typical *rigida*.

Myriotrochus bathybius,[1] sp. nov.

Plate 4, fig. 3.

Length of preserved specimen, 33 mm.; diameter, 8 mm. Oral disk, 8 mm. across, with scattered yellow-brown papillae, most numerous near mouth, each about one fourth of a millimeter high. Tentacles twelve, each with three minute digitations on each side. Color, gray; outside of circle of tentacles there are seven dark spots lying between tentacle-bases. Calcareous ring stout, with distinct projecting points on the anterior margin of both radial and interradial pieces; the posterior margins are, on the contrary, almost straight. Stone-canal single, short, compact, free. Polian vessel, single, long. Genital glands well developed on each side.

Calcareous particles consist of wheels alone, no deposits of any kind being found in the tentacles or oral disk. Wheels (Plate 4, fig. 3) very few and widely scattered; it may be that their scarcity is due to the abrasion of the epidermis during the long and rough journey to the surface in the trawl. Of the four seen, one had twelve, two had thirteen and one had fourteen spokes. Only two of these wheels were sufficiently uninjured to make the count of the teeth on the inner margin accurate; in a wheel with twelve spokes there were thirty-seven teeth and in one with thirteen spokes there were thirty-eight teeth. Evidently then the wheels in this species have typically thirteen spokes with the teeth three times as numerous. The most important feature of the wheels, however, is the hub which, as will be seen from the figure, is relatively large and has a circle of small oval perforations around the center. A few developmental stages of the wheels were found which explain this curious arrangement. As is the case with all wheels in the Synaptidae, the first beginning is a minute circular disk. Projections soon arise all around the margin and these lengthen into the spokes, which ultimately expand bilaterally at the tip, these expansions fusing with each other and forming the rim of the wheel. In the present species when the length

[1] $\beta\alpha\theta\acute{\iota}\beta\iota o\varsigma$ = deep-living, in reference to the great depth at which it occurs.

of the spokes is somewhat greater than the diameter of the original hub, a swelling appears near the middle of each spoke and as these swellings widen they come in contact and fuse with each other, leaving the circle of small oval holes, which apparently never fill up. The number of these holes thus corresponds to the number of spokes. The three wheels which were sufficiently complete to permit measurement were 240, 300 and 340 μ in diameter, with marginal teeth about.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

One specimen.

Although the superficial resemblance of this specimen is very close to that of the smaller of the two specimens of *M. giganteus*, the wheels are so different, it is impossible to consider it simply an aberrant example of the same species. The question of the relationships of *bathybius* is discussed under *giganteus*.

Myriotrochus giganteus,[1] sp. nov.

Plate **4**, fig. 4.

Length 53 mm.; diameter 20 mm.; oral disk 12 mm. across. Form distinctly like Molpadia but for the lack of any caudal appendage. Smaller specimen, very much contracted and deformed, 35 mm. long, 9 mm. in diameter anteriorly but only 4 mm. at middle and posteriorly, and with oral disk 7 mm. across. Tentacles twelve, with 5–7 short but distinct digits on each side. Color, of smaller specimen gray; of holotype, light brown on a gray foundation, with area around anus and another area just back of and including tentacles on dorsal side, deep purple. Calcareous ring stout, with the radial pieces having rounded posterior, and broad blunt anterior, projections, and the interradial pieces similar except that the anterior projection is pointed. No stone-canal was found. Polian vessel single, small. Genital glands well developed on each side.

Calcareous particles are wheels alone, no deposits of any kind being found in the tentacles or oral disk. Wheels (Plate **4**, fig. 4) fairly numerous but widely scattered; somewhat more numerous dorsally near the two ends of the animal than elsewhere, apparently, but this may be result of greater abrasion near middle of body. Of twenty-seven wheels observed sufficiently perfect to permit counting spokes, two had ten, nine had eleven, eight had twelve, seven had thirteen, and one had fourteen spokes, an average of not quite twelve spokes per wheel.

[1] γιγαντεῖος = like a giant, in reference to the exceptionally large size for a Myriotrochus.

Only twenty-three wheels were suitable for counting the marginal teeth and in these there is great diversity, the number ranging from twenty-one to thirty; the average number per wheel is a trifle more than twenty-four, or just about twice the number of spokes; the largest relative number is twenty-seven teeth for ten spokes and the smallest is twenty-two teeth for thirteen spokes. Hub of wheel small and solid, its diameter .20–.25 of wheel diameter. Wheels range from 190 to 315 μ across with the marginal teeth 30–50 μ long.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

Two specimens.

The occurrence of two species of Myriotrochus south of the equator and at a depth of over two thousand fathoms is one of the most extraordinary zoölogical discoveries made by the ALBATROSS during her 1904–1905 cruise. The genus has not hitherto been known south of Norway, Newfoundland, Alaska, and northern Japan, nor at a depth of more than a few hundred fathoms. The species taken at station 4647 are very different in general appearance from any of the known forms, but *giganteus* is much like the common subarctic species *rinkii* in the character of its wheels. The wheels of *giganteus* average a trifle larger than in *rinkii* but the difference is insignificant. The spokes, however, are noticeably fewer (10–14, average almost twelve, as against 12–22, average seventeen) and much wider, while the hubs are larger (.20–.25 wheel-diameter as against about .16). The marginal teeth are relatively more numerous in *giganteus*, where they average almost exactly double the number of spokes. The wheels in *bathybius* are conspicuously different from those of any other member of the genus. Both the tropical species seem to be much larger and stouter than *rinkii*, the largest of the previously known species, although there is not great difference in length, since Östergren reports specimens of *rinkii* up to 70 mm. long in life. The superficial resemblance of *giganteus* in form and color to a Molpadia is very striking and only the examination of the calcareous particles proves how misleading the resemblance is.

It was hard to convince myself that the holotype of *bathybius* was not merely an aberrant individual of *giganteus*, but the wheels are too markedly and consistently different to support such an idea. Moreover the differences in the digitation of the tentacles and in the calcareous ring cannot be ignored and no other conclusion seems possible than that these two closely-allied species live together on the ooze in the great depths of the eastern Pacific. It is an environment peculiarly suited to holothurians, as is well shown by the fact that nine different species were taken in the single haul of the trawl at station 4647.

Molpadiidae.

Molpadia bathybia,[1] sp. nov.

Plate **3**, fig. 2; Plate **4**, fig. 5, 6.

Length 50 mm., of which about 5 mm. is caudal appendage; diameter about 17 mm. Tentacles contracted out of sight and whole oral disk more or less shrunken. Body-wall, very thin. Color, gray. No phosphatic deposits. Calcareous particles, tables only but these very abundant though not crowded. Tables not perfectly symmetrical but not notably asymmetrical, and the disks never have projecting rods, nor do they tend to narrow down in the posterior end into supporting rods; disks (Plate **4**, fig. 5) 200–300 μ across with three primary holes, three secondary holes, often nearly as big, and not uncommonly additional marginal holes, so that there may be twenty or even more perforations; spire (Plate **4**, fig. 6) made up at base of three rods which quickly fuse into a smooth straight rod with blunt tip, 200–250 μ high.

Station 4670. Peru: west of Palominos Light House, 105 miles. 3,209 fms. Bott. temp. 35.4°. Fne. dk. br. m.
Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Two specimens.

The holotype is from station 4672. The other specimen (Plate **3**, fig. 2) is slightly smaller but has the same proportions, with the tentacles somewhat less contracted and apparently fifteen in number. There are no phosphatic bodies and the calcareous particles are as in the holotype. This species is nearly allied to *M. arctica* but the tables are markedly different. In the absence of phosphatic bodies and supporting rods and the total lack of anchors and plates, *bathybia* is easily distinguished from all the species hitherto known from the eastern tropical Pacific.

Molpadia holothurioides.

Plate **3**, fig. 1.

Cuvier, 1817. Reg. Anim., **4**, p. 24.
Molpadia musculus Risso, 1826. Hist. Nat. Europe, **5**, p. 293.

In Apodous Holothurians (Washington, 1908[2]), I accepted *holothurioides* as the type of the genus Molpadia but did not accept it as a valid specific name within the genus, placing it instead as a questionable synonym under *M. mus-*

[1] $\beta\alpha\theta\acute{\upsilon}\beta\iota\omega\varsigma$ = deep-living, in reference to the unusual depth of its habitat.
[2] Although dated 1907, this book was not issued until January, 1908.

culus. Such a course now seems illogical and the acceptance of Cuvier's specific name is the most satisfactory solution of the difficulty. There is little doubt that Cuvier and Risso were dealing with the same species and since Ludwig has clearly shown what the species is, described as *musculus* by Risso, that species ought to bear Cuvier's name.

The species has a wide distribution and probably the name in its present sense really covers several valid species, but the specimens in the present collection throw no light on the matter. They range from 30 to 115 mm. in length. The smallest have very insignificant caudal appendages, relatively few phosphatic bodies, and many anchors; several are evidently *Ankyroderma spinosum* Ludwig. The largest specimens are quite red from the crowded phosphatic deposits, and their caudal appendages are relatively long.

The two colored figures given, obviously do not represent a single species. There is little reason to doubt that Plate 3, fig. 1 represents an adult *holothurioides*, though the color is more roseate than would be expected and the absence of a caudal appendage is notable. But Plate 3, fig. 5, while almost certainly a Molpadia can hardly be *holothurioides*. The figure is published in order to record the occurrence in the Eastern Pacific of a holothurian, having this most unusual green color. The drawing is based on a specimen recorded from station 4630, but there is no molpadiid in the collection now from that station; at 4631, however, *M. holothurioides* was taken.

Station 4631. Panama: off Mariato Point, 72 miles. 774 fms. Bott. temp. 38°. Gn. s.
Station 4651. Peru: west of Aguja Point, 111 miles. 2,222 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Twenty specimens.

Ceraplectana trachyderma.

H. L. Clark, 1908. Apod. Hol., p. 39.

The rediscovery, off the coast of Peru, in very deep water, of this remarkable holothurian hitherto known only from the type-locality in the vicinity of the Aleutian Islands, is one of the interesting results of the 1904–1905 expedition. The specimens are in very good condition, except that one has all but one of the curious horny tentacles missing; apparently they have been torn off. The larger specimen is 52 mm. long and 17 mm. in diameter, with a caudal appendage about 9 mm. in length. The smaller specimen is about four fifths as large. The color is gray finely speckled with brownish red, but the oral disk

is nearly white with the tentacles bright brown in sharp contrast. In no important particular do these specimens differ from those originally described.

Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Two specimens.

CUCUMARIIDAE.

Cucumaria abyssorum.

Plate **2**, fig. 5.

THÉEL, 1886. CHALLENGER Hol., pt. 2, p. 66.

The specimens range from 50 to 75 mm. in length and call for little comment. Examination of the body-wall seems to indicate that the calcareous particles decrease in number with age. At any rate, the largest specimens lack spicules more or less completely.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gn. m.
Station 4651. Peru: west of Aguja Point, 111 miles. 2,222 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.

Thirteen specimens.

Pseudocucumis africana.

Cucumaria africana SEMPER, 1868. Holothurien, p. 53.
Pseudocucumis africana LUDWIG, 1888. Zool. Jahrb. Syst., **3**, p. 815.

On February 8, 1900, six specimens of this very well-marked species were taken at Kusaie in the Caroline Islands, on a reef. This seems to be the most easterly record for the species, which is now known from Japan on the north to Torres Strait on the south and from Portuguese East Africa eastward to Kusaie.

Echinocucumis bitentaculata.

Sphaerothuria bitentaculata LUDWIG, 1893. Bull. M. C. Z., **24**, p. 112.

It is difficult to believe that there is any generic distinction between *Echinocucumis typica* Sars and Ludwig's *Sphaerothuria bitentaculata*. In the contracted condition in which they are ordinarily taken, it is very difficult, if not impossible, to determine the number and relative sizes of the tentacles, and it is doubtful whether the supposed differences are real and constant. R. Perrier considers Ludwig's genus a synonym of E. Perrier's Ypsilothuria and of this

there can be little doubt, but I believe Perrier's genus synonymous with Sars's. Whether there is more than one species in the genus is not yet satisfactorily determined for the diversity of form even in specimens from the same spot is very great, and it is yet to be shown how much of this is natural and how much is artificial, *i. e.* the result of contraction during preservation. The specimen in the present collection is 13 mm. long and 10 mm. high; the anal tube is 2–3 mm. long but the oral end is strongly contracted and no tentacles are visible.

Station 4631. Panama: off Mariato Point, 72 miles. 774 fms. Bott. temp. 38°. Gn. s.

One specimen.

Pelagothuriidae.

Pelagothuria natatrix.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 111.

This remarkable pelagic holothurian must be quite common in the eastern tropical Pacific for it is well represented in both of the Albatross collections. But all of the specimens are in poor condition and offer nothing additional to Ludwig's very full description. They are all of about the same size, apparently adult. The following list of stations is interesting as throwing much light on the distribution.

Station 16.[1] Eastern Tropical Pacific (660 miles northeast of the Marquesas), 2° 38′ N., 137° 22′ W. 2,440 fms.
Station 17. Eastern Tropical Pacific, 0° 50′ N., 137° 54′ W., 2,463 fms.
Station 4641. Galapagos: Hood Island, 12 miles southeast of Ripple Point, 633 fms.
Station 4645. Galapagos: south of Chatham Island, 1,955 fms.
Station 4646. Eastern Tropical Pacific, 4° 1′ 36″ S., 89° 16′ 18″ W., 2,058 fms.
Station 4715. Galapagos: southwest of Hood Island; tow at 300 fms.
Station 4716. Galapagos: 55 miles southwest of Hood Island; surface tow.
Station 4717. Eastern Tropical Pacific, 5° 10′ S., 98° 56′ W.; tow at 300 fms.
Station 4721. Eastern Tropical Pacific, 8° 7′ 30″ S., 104° 10′ 30″ W.; tow at 300 fms. and up to surface.
Station 4742. Eastern Tropical Pacific, 0° 3′ 24″ N., 117° 15′ 48″ W.; tow at 300 fms.

Thirty-three specimens.

Elpidiidae.

Parelpidia anamesa,[2] sp. nov.

Plate **3**, fig. 3.

Length 85 mm.; diameter, 15 mm. Color, light yellow-brown. Body-wall very thin and soft. Tentacles ten. The specimen is in such poor condition and so filled with mud, none of the details of the internal organization could

[1] Bottom temperature and character of bottom omitted, since the species is pelagic.
[2] ἀνάμεσος = intermediate, in reference to the fact that the species seems to connect Parelpidia and Peniagone.

be made out; not even a calcareous ring was detected. Posterior end of body, flattened. Pedicels present around posterior end, but their number, size, and relative positions could not be determined. Calcareous particles characteristic; in skin of dorsal surface are quadriradiate spicules, each of the four, only very slightly thorny branches curved inward rather strongly, while from their common center arises an outwardly directed nearly smooth spine; the curved rods are 350–550 μ long and the projecting spine 300–400 μ; in the ventral skin, the spicules are smaller with less curved rods and two to four low, rough, projecting spines or knobs, much as in *Peniagone intermedia*.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

One specimen.

It is by no means sure that this species is properly referred to Parelpidia rather than to Peniagone but the elongated form and the apparent absence of any dorsal appendage seem to justify the position given. The spicules of the dorsal surface are the really characteristic feature and will serve to distinguish even more badly preserved specimens than the holotype (Plate 3, fig. 3). Judging from the colored drawing, made from life, there are only three pedicels on each side of the body and these are widely separated. There seem to be none around the flattened posterior end.

Scotoplanes murrayi.

Plate 3, fig. 6.

Elpidia murrayi Théel, 1879. Bih. K. Sven. Vet. Akad. Handl., 5, no. 19, p. 16.
Scotoplanes murrayi Théel, 1881. Challenger, Hol., pt. 1, p. 34.

The Albatross specimens are all much larger than the holotype of *murrayi*, ranging from 55 to 85 mm., but there seems no good reason for considering them specifically distinct. The calcareous particles are actually larger than in Théel's specimen but relatively they are about the same. The rods are 1–1.25 mm. long and correspondingly stout; they are abundant; the C-shaped bodies are also very plentiful and relatively large. The skin is very thin and owing to the abundance of the spicules is quite brittle. The left-hand papilla in one specimen (Station 4672) is double. In the same specimen, there are only *five* papillae in one lateral series, though there are *six* in the other. This specimen is further remarkable for having contained a parasitic worm, apparently an Ichthyonema.

Station 4651. Peru: west of Aguja Point, 111 miles. 2,222 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2° Fne. dk. br. infus. m.

Four specimens.

Periamma tetramerum,[1] sp. nov.

Plate 2, fig. 4.

Length, 50 mm.; diameter, 15 mm. Body-wall very thin and delicate. Color, pale yellowish brown and grayish; the gray areas appear to be where the brown is rubbed off. Tentacles ten. Pedicels, eight on each side, the most anterior largest (2 mm. long or more), situated anterior to middle of body; the posterior four smallest and more or less united together. About 12 mm. back of anterior end is a transverse crest, 8–9 mm. wide and 4 mm. high, more or less lobed, but not markedly so; this crest is apparently made up by the fusion of two pairs of processes, *i. e.* four projecting papillae, and back of it, there is on each side a similar papilla 1.5 mm. high. General appearance much like a small *Scotoplanes robusta*. Internal anatomy completely indeterminable owing to the whole interior being densely packed with mud.

Calcareous particles very characteristic. In deeper layer of skin are numerous C-shaped (sometimes S-shaped) bodies, 100 μ long. External to these is a layer of very diversified thorny spicules, generally *tetramerous;* each forms a more or less perfect cross with two opposite arms shorter than the other two; rarely the spicules are trimerous or pentamerous; each arm of a spicule is usually about 100 μ long but often they are less. Here and there among these crosses are much stouter, thorny rods, 200–300 μ long; these often have a short branch, at a right angle, on one side, near the middle.

Station 4670. Peru: west of Palominos Light House, 105 miles; 3,209 fms. Bott. temp. 35.4°. Fne. dk. br. m.

Six specimens.

These specimens seem to have suffered considerable damage in the ascent of the trawl, for in the largest ones the outer spicule layer is nearly all rubbed off leaving only the C-shaped particles. The dorsal crest is more or less damaged but its form and size are fairly recognizable. The number, size, and arrangement of the pedicels is also distinguishable in most of the specimens. The spicules are very characteristic and there will be no difficulty in recognizing examples of the species where enough of the epidermis is intact to permit the existence of the crosses to be determined.

[1] τετράμερος = having four parts, in reference to the characteristic spicules.

Peniagone bispiculata,[1] sp. nov.

Length about 45 mm.; width, back of middle, about 30 mm. Body oval, narrower in front, very flat in the preserved specimens but probably less so in life. Tentacles ten, relatively large. Oral surface with 10–12 very large pedicels surrounding it, beginning near mouth on each side; even in their contracted condition these pedicels are several millimeters long and 2 mm. thick at base. Dorsal crest thin, rather low, rounded, about 10 mm. wide by 5 mm. high, placed close to anterior end of body. On right side, 12 mm. back of crest, is a papilla 6 mm. long by 2 mm. thick, pressed down flat against body; no corresponding papilla can be detected on the left side but it may have been broken off, and as the whole body-surface is very much wrinkled and folded, its point of attachment is no longer to be found. Color, gray (holotype) or pinkish (paratypes).

Calcareous particles not very distinctive except by size; they resemble those of *P. intermedia* but are more slender and have more pointed tips to the four inwardly curved arms; these arms are 100–120 μ long; here and there among these small and very numerous spicules are scattered abruptly larger ones with arms 150–170 μ long.

Station 17. Eastern Tropical Pacific, 0° 50′ N., 137° 54′ W., 2,463 fms. Bott. temp.? Lt. yel.-gy. glob. oz.

Three specimens.

While this new Peniagone resembles *vitrea* and *intermedia* in certain particulars, the arrangement of the large pedicels and the form of the body are very different from what is found in either of those species. The size of the spicules and particularly the existence of two very different sizes are also distinctive points. It is at least worthy of note that while the holotype is fairly well preserved the paratypes are in very bad condition, each of them being split open down the back for the entire length. The appearance suggests that with the release from the bottom-pressure these specimens exploded leaving only the empty skin, which had proved weakest along the middorsal line.

Peniagone intermedia.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 109.

The specimens referred to this species are in such poor condition, that their identification is far from certain. They are supposed to belong to *inter-*

[1] *bispiculata* = having two kinds of spicules, in reference to the two distinct sizes in the calcareous particles.

media because of a fairly close similarity in calcareous particles but whether the dorsal appendage and the pedicels are also similar, it is out of the question to determine. They certainly add nothing to our knowledge of the species.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infns. m.

Ten specimens.

Peniagone setosa.

Peniagone vitrea var. *setosa* LUDWIG, 1893. Bull. M. C. Z. **24**, p. 109.

Comparison of the present specimen with a cotype of Ludwig's variety has satisfied me that the two are identical and that both are perfectly distinct from *vitrea* Théel. I therefore raise the variety to full specific rank. It is easily recognized by the abundance and large size of the spicules, the curved arms of which are 300–530 μ in length, with the outwardly directed spines, 300–470 μ. The ALBATROSS specimen is lighter and less gray than the cotype and the crest is much less evident. The length is rather more than 50 mm.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

One specimen.

Peniagone vitrea.

THÉEL, 1881. CHALLENGER Hol., pt. 1, p. 50.

Although the specimen at hand is badly rubbed and lacks its tentacles, and although the integument is not at all glassy or "hard, brittle and rough," I feel little doubt about the identity, for the shape of the body, the arrangement of the pedicels and the calcareous particles agree well with Théel's description. The color is yellowish white and the body-wall is quite opaque. The body posterior to crest is 50 mm. long, anterior to crest is 30 mm. and its width is 25 mm. The crest is 25 mm. high and while its margin is irregular there are no definite four projections visible. There is a note with the specimen indicating that the color in life was "pink."

Station 17. Eastern Tropical Pacific, 0° 50′ N., 137° 54′ W., 2,463 fms. Bott. temp.? Lt. yel.-gy. glob. oz.

DEIMATIDAE.

Oneirophanta mutabilis.

THÉEL, 1879. Bih. K. Sven. Vet. Akad. Handl., **5**, no. 19, p. 6.

The present series confirms Théel's statements concerning the diversity shown by this species. I doubt very much the validity of the species which

have been proposed in Oneirophanta during the period since the CHALLENGER Report was published. They seem to me to come well within the range of diversity shown by *mutabilis*. If all are valid, the specimen in the present collection from Station 4732 may well be made the type of a new species. It is about 80 mm. long and the pedicels and processes are so few and small they might easily be overlooked; the body-wall is like thin glass and the body is full of fine light-colored sand. The other specimens range from 45 to 200 mm. in length and are for the most part glassy and nearly white but one of the largest specimens is quite brown. The extent of digitation shown by the tentacles and the number of midventral pedicels are characters of very great diversity. The number and size of the lateral pedicels also show a great range as Théel pointed out; in one specimen 150 mm. long, the pedicels are 20 mm. long by 6 mm. in diameter while the marginal papillae are 45 mm. long and 8 mm. thick at the base. The calcareous plates are very characteristic and while they show considerable diversity, the specific features are not obscured.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gr. m.
Station 4651. West of Peru, 5° 41′ 42″ S., 82° 59′ 42″ W., 2,222 fms. Bott. temp. 35.4°. Stky. fne. gy. s., trace of shore-mud.
Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 36′ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn.m., mang. nod.
Station 4732. Eastern Tropical Pacific, 16° 32′ 30″ S., 119° 59′ W., 2,012 fms. Bott. temp. 34.8°. Lt. gy. glob. oz.

Sixteen specimens.

Scotodeima parvispiculatum,[1] sp. nov.

Plate 4, fig. 7, 8.

Length, 60 mm.; breadth, 12 mm. Color, dirty white. Body very flat, in bad condition, more or less eviscerated. Tentacles wanting. Dorsally there are six rows of conical papillae, of which two series are along each margin; all the papillae look rubbed but they probably never had very long tips. Arrangement of pedicels on ventral surface not distinguishable but there were probably none in midventral ambulacrum at least anteriorly. Marginal papillae smaller and forming a marginal fringe anteriorly. Mouth ventral. Anus dorsal.

Calcareous particles remarkably small and quite characteristic. They

[1] *parvispiculatus* = provided with little spicules, in reference to the small size of the calcareous particles.

usually have 4 rays or arms (Plate 4, fig. 7) but often there are 5 or more (Plate 4, fig. 8); the arms are flat, perforated with several holes at their enlarged tips, and occasionally have little spines on the sides. The whole spicule is rarely 200 μ long, while somewhat similar spicules in *S. protectum* are about 700 μ long.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 36′ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

One specimen.

This species is readily distinguished from other known species of the genus by the very small and characteristic spicules. It is unfortunate that the condition of the specimen does not permit a better knowledge of its external features and internal anatomy.

Scotodeima setigerum.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 109.

Although these specimens are in fairly good condition, they contribute nothing of importance to Ludwig's full account (1894, Mem. M. C. Z., **17**, p. 74–79). They range in length from 55 to 88 mm.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gr. m.

Seventeen specimens.

Laetmophasma fecundum.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 109.

The specimen, about 50 mm. long, is in such wretched condition that there is little certainty about the identification. But there is no doubt that some at least, of the now more or less decalcified, deposits were wheels like those of *L. fecundum* and there is nothing improbable about the specimen representing that species.

Station 4653. West of Peru, about 17 miles, 5° 47′ S., 81° 24′ W., 536 fms. Bott. temp. 41.3°. Dk. br. gy. shore m.

One specimen.

Capheira sulcata.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 109.

The representatives of this species are in very bad condition indeed but the calcareous particles agree well with Ludwig's description and figures (1894,

Mem. M. C. Z. **17**, p. 100, plate **6**, fig. 1–5). In one specimen it is possible to find the tentacles and there seem to be only *sixteen*.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 35′ 36″ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.

Two specimens.

Psychropotidae.

Euphronides dyscrita,[1] sp. nov.

Plate **2**, fig. 3.

Length, 75 mm.; width, 17 mm. or more. Dorsal appendage, 18 mm. long, 10 mm. wide at base, 5 mm. wide at tip; situated only 8 mm. from posterior end of body; somewhat flattened and with tip rounded. Mouth and anus, ventral. Tentacles apparently 18, but the number is hard to make out. Color, yellow-brown above; deep purple below; tentacles, very deep purple. There is a well-marked and frequently lobed margin but it is in too poor condition to permit its exact character to be determined.

Calcareous particles strongly arcuate 4-armed bodies with thorns but no conspicuous spines either at center or elsewhere; arms 125 μ long or longer and occasionally twice that, but the large ones are very slender. Though very abundant dorsally, the spicules are not crowded there; if present ventrally they are more scattered and are concealed by the heavy pigmentation.

Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Two specimens.

The holotype is in poor condition but the paratype is much worse and gives no assistance as to the generic and specific characters. It is light gray above with a brownish tinge but most of the external layer of skin is rubbed off. It shows the well-marked, lobed margin but lacks the dorsal appendage or at best, possesses but a fragment. The species looks like a short-tailed Psychropotes but the appendage is so short and the calcareous particles are so strongly arcuate, it seems better placed in Euphronides. The position of the dorsal appendage, and the calcareous particles serve to distinguish it from any other member of the genus.

[1] *δύσκριτος* = hard to determine, in reference to the doubtful generic position.

Euphronides verrucosa.

Plate 1, fig. 2.

Ludwig, 1893. Bull. M. C. Z. 24, p. 107.

The representative, from station 4742, of this fine species is in fairly good condition and is a very large one, nearly 200 mm. long by 50 mm. wide. The colors in life are shown on Plate 1, but in the preserved specimen, the lower surface is very dark purple while the upper side is light, dull rose-purple. There are only sixteen tentacles. The characteristic calcareous spicules of the dorsal side are very conspicuous.

The specimen from station 17 is labeled by Mitsukuri "Euphronides bifurcata K. & V." and is accompanied by the following note:—

"Specimen very much contracted and distorted. 16 tentacles. A little behind the posterior, and one-third of the total length on the dorsal surface, 1 pair of not very long nor very large appendages, 1.1 cm. long. 2 more pairs of much smaller appendages in front. At the dorso-ventral border, irregular lobed brim. Body not very flat. Posterior part dorsal high. Ventral surface sole-like, flat. A row of paired pedicels on the median ventral ambulacrum. On the dorsal, a number of warts, each supported by one four-branched spicule, from which the central needle projects."

I have examined the specimen with great care but fail to find any dorsal appendages nor can I distinguish the specimen in any adequate way from that from station 4742 which I have referred to *verrucosa*. Whether Mitsukuri made a mistake, or whether the mistake is mine, or whether *bifurcata* K. & V. is identical with *verrucosa* Ludwig, more material alone can determine.

Station 17. Eastern Tropical Pacific, 0° 50′ N., 137° 54′ W., 2,463 fms. Bott. temp.? Lt. yel.-gy. glob. oz.

Station 4742. Eastern Tropical Pacific, 0′ 3′ 24″ N., 117° 15′ 48″ W., 2,320 fms. Bott. temp. 34.3°. Fne. lt. gy. glob. oz.

Two specimens.

Psychropotes raripes.

Plate 1, fig. 1.

Ludwig, 1893. Bull. M. C. Z., 24, p. 107.

The two representatives of this species are very big adults and are much the largest deep-water holothurians in the collection. The specimen from 4658 is in remarkably perfect condition; the body is 170 mm. long, with the tail 110 mm. in addition; the maximum width for the body, as well as for the tail, which has convex lateral margins, is 45 mm. The tail is very flat and distinctly notched at tip. The general color is gray above becoming purple below, with the lower surface of the tail reddish; tentacles purple. The specimen from 4721 (Plate 1, fig. 1) is not in as fine condition but is still

larger; the body, 220 mm., the tail 180 mm., and the width 50 mm. Mr. Agassiz states that in life this specimen was 55 cm. long. The tip of the tail is less distinctly notched than in the other specimen. The color is violet much faded dorsally, where it is almost gray; the tentacles are brown.

Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 36′ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m., mang. nod.
Station 4721. Eastern Tropical Pacific, 8° 7′ 30″ S., 104° 10′ 30″ W., 2,084 fms. Bott. temp.? Lt. br. glob. oz.

Two specimens.

Benthodytes glutinosa.

Plate **2**, fig. 1.

R. Perrier, 1896. Compt. Rend., **123**, p. 903.

This species, originally described from the Atlantic, has since been recorded from the Indian Ocean by Koehler and Vaney. The present specimen appears to agree with these latter in the entire absence of spicules. Otherwise the agreement with Perrier's later, fuller description and figures (1902, Travailleur et Talisman Hol., p. 462; plate 13, fig. 5 and plate 20, fig. 31) is very close. The differences between *glutinosa* and *typica* do not seem to be very weighty and it is probable that the two are identical.

Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.

One specimen.

Benthodytes regularis,[1] sp. nov.

Plate **2**, fig. 2.

Length, 105 mm.; thickness about 15 mm., but when both margins are spread flat, the width is 22 mm. Seen from below the appearance is much like Théel's figure of *B. sanguinolenta* var. *marginata* (1886, Challenger Hol., plate 25, fig. 2) but the upper surface is very different from that of *marginata*. On each dorsal ambulacrum is a series of fourteen or fifteen papillae in a single row; these begin 25 mm. back of anterior end of body, are of nearly uniform size and quite evenly spaced; each is about 2–2.5 mm. high by 1.5 mm. in basal diameter; the form is bluntly conical. Mouth ventral but anus dorsal. Anterior end quite flattened. Midventral line of pedicels distinct but they are small and fully retracted; they are wanting on the anterior region for a distance of 20 mm. or more. Tentacles not permitting an accurate count,

[1] *regularis* = according to rule, in reference to the regular arrangement of the dorsal papillae.

probably fifteen but perhaps only twelve. Color, dull purplish gray; tentacles, margin (at least orally) and midventral series of pedicels, deep purple.

Calcareous particles apparently wanting ventrally but scatteringly present dorsally; they have the form of crosses with nearly equal, slender, thorny arms; each cross is about 125 μ across but here and there were fragments of larger crosses at least 250 μ across. The outer layer of skin is badly rubbed off and as the crosses are in this layer, it is probable the fragmentary condition of the larger crosses is due to rough treatment in the trawl. Perhaps the absence of spicules ventrally is due to the same cause.

Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gr. m.

One specimen.

This species appears to be well characterized by the regular arrangement of the conspicuous dorsal papillae but the species of Benthodytes are most perplexing, particularly as they usually lack spicules or possess only such as are not very distinctive. Specific limits within the genus, as at present drawn, must be considered purely tentative.

Benthodytes sanguinolenta.

THÉEL, 1881. CHALLENGER Hol., pt. 1, p. 104.

This species is a convenient catch-all for specimens which are more or less elongated, have no calcareous particles, and lack any other distinctive feature. Whether more than a single species has been, or is here, listed under the name, it is impossible to say, owing to the almost uniformly bad condition of the material. The specimens from the following stations are from 50–80 mm. long and hence probably young, excepting one in fairly good condition, which is 140 mm. long by 15 mm. thick. The specimen from 4740 appears to have only thirteen tentacles.

Station 4651. Peru: west of Aguja Point, 111 miles. 2,222 fms. Bott. temp. 35.4°. Fne. stky. gy. m.
Station 4658. Eastern Tropical Pacific, 8° 30′ S., 85° 36′ W., 2,370 fms. Bott. temp. 35.3°. Fne. gn. m. mang. nod.
Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.
Station 4732. Eastern Tropical Pacific, 16° 32′ 30″ S., 119° 59′ W., 2,012 fms. Bott. temp. 34.8°. Lt. gy. glob. oz.
Station 4740. Eastern Tropical Pacific, 9° 2′ S., 123° 20′ W., 2,422 fms. Bott. temp. 34.2°. Dk. gy. glob. and rad. oz.

Eleven specimens.

Holothuriidae.

Mesothuria megapoda,[1] sp. nov.

Plate 4, fig. 9, 10.

Length about 40 mm. Color, pinkish white. Eviscerated and in bad condition so even the generic position is not certain, but the calcareous tables show such similarity to those of *M. murrayi* and *M. multipes* that there is little doubt the specimen represents a species of Mesothuria. Body rather uniformly covered with large pedicels, 2–3 mm. long and .50–.75 mm. in diameter; there is no arrangement in series or bands, nor are any of the pedicels conspicuously larger than the others. There are no supporting rods in the pedicels but there are well-developed terminal plates.

Calcareous particles consist of very numerous tables (Plate 4, fig. 9) with spires 100–135 μ high; the three rods making up the spire are enlarged, curved outwards and rough at the tip. The disks (Plate 4, fig. 10) are 150–200 μ across and are perforated with seven nearly equal holes, one at center with six around it; while they are not all exactly alike, they exhibit little diversity.

Station 4742. Eastern Tropical Pacific, 0° 3′ 24″ N., 117° 15′ 48″ W., 2,320 fms. Bott. temp. 34.3°. Fne. lt. gy. glob. oz.

One specimen.

Although the specimen is in such poor condition its specific characters are well marked. It is distinguished at once from *M. multipes* by the larger pedicels, the presence of a well-developed terminal plate and the larger, lower tables. In *multipes*, the disks of the tables are only 75–100 μ across, while the spires are much more than that. From *M. murrayi*, *megapoda* may be readily distinguished by the uniform and large size of the pedicels and by the difference in the tables. In *murrayi*, the disks are only 70–120 μ across but have more numerous perforations.

Mesothuria multipes.

Mesites multipes Ludwig, 1893. Bull. M. C. Z., **24**, p. 106.
Mesothuria multipes Ludwig, 1894. Mem. M. C. Z., **17**, p. 31.

The specimen at hand has eviscerated so nothing can be said of its internal anatomy. Otherwise it agrees well with Ludwig's description except that the tentacles are very dark colored, deep purplish. It is 60 mm. long.

[1] μεγάποδος = having large feet, in reference to the unusually large pedicels.

Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.

One specimen.

Mesothuria multipora,[1] sp. nov.

Plate 4, fig. 11–13.

Length, 140 mm.; diameter, about 50 mm. Color, gray. Internal anatomical details not definable as the specimen has eviscerated. Pedicels scattered all over body, but most sparsely dorsally; dorsal pedicels about 1 mm. long by .25 mm. in diameter; the pedicels are much more numerous and twice as large along the sides. Skin in close, horizontal, nearly black folds along each side, forming a fairly distinct border between dorsal and ventral surfaces.

Calcareous particles present in the form of tables (Plate 4, fig. 11) alone. These are all of the same type and show diversity chiefly in the number of perforations in the disk; spire with one cross-beam, about 75 μ high and 50 μ across the top (Plate 4, fig. 13) which bears about sixteen teeth; disk (Plate 4, fig. 12) squarish, 200 μ across, with a somewhat square central hole and thirty to fifty more or less circular perforations of small size.

Station 74. Tahiti: 4.8 miles N., 82° W. from Point Venus, 772 (?) fms. Bottom temp.? Fne. vol. s. (?).

One specimen.

This specimen was labeled by Professor Mitsukuri "*Mesothuria intestinalis* Asc. Rathke (*Hol. Verrillii* Théel)." I have compared it with both *intestinalis* from Norway and cotypes of *verrilli* from the West Indies, and the difference in the tables is striking and apparently constant. I am satisfied that *verrilli* is a perfectly valid species and that the present Tahitian form is entirely distinct from either the European or the West Indian species.

Synallactes aenigma.

Plate 3, fig. 4.

Ludwig, 1893. Bull. M. C. Z., **24**, p. 106 (*nomen nudum*). 1894, Mem. M. C. Z., **17**, p. 26.

This seems to be one of the characteristic species of the Eastern Tropical Pacific and the present series throws no little light on its structure and variability. Instead of merely eviscerating, this species seems to have also the unusual habit of actually throwing off the skin. Either as a result of rough treatment in the trawl or because of the decreased pressure at the surface, or perhaps for both reasons, the skin, which is quite thick and tough splits down the middorsal

[1] *multiporus* = having many pores, in reference to the disk of the calcareous tables.

line and becomes entirely detached from the body-muscles, which are contracted into a firm cylindrical mass, evisceration having previously occurred. The skin around the mouth and the tentacles remain on the muscular mass.

The specimens at hand range from twenty-eight to nearly 100 mm. in length and show great diversity in the size, number and conspicuousness of the pedicels and papillae. The pedicels in the midventral radius may be so few and small, that they would readily escape notice but they may be fairly conspicuous. In one specimen there is scarcely a trace of dorsal papillae and even the marginal ones are indistinct, while in a slightly smaller specimen (Plate 3, fig. 4) from the same station, practically the whole dorsal surface is occupied by a double series of large conical papillae in each ambulacrum and a marginal series on each side.

In the larger of two specimens from station 4651, the calcareous ring is well developed and resembles that of *S. alexandri* as described by Ludwig, while in the smaller one, I fail to find any calcareous ring at all, the condition which Ludwig found in his specimens of *aenigma*. Even the calcareous tables show some diversity; in a specimen from 4656, the tables are rather slender and have a smooth spire while in another from the same station, the tables are stouter and have rough spires.

Probably many of the differences shown by preserved specimens, in form, size, and appearance of pedicels and papillae are artificial, but there can be little doubt that the species does show more or less diversity in nearly all its characters. There are also changes due to age which cannot be ignored. Young specimens have remarkably slender tables; the basal arms are very slender and the spire, about twice the basal diameter, is very long, slender, and thorny. Apparently with age, the spires become stouter and smoother as well as shorter, and the basal arms are noticeably thicker.

Station 4649. Eastern Tropical Pacific, 5° 17′ S., 85° 19′ 30″ W., 2,235 fms. Bott. temp. 35.4°. Fne. stky. gr. m.

Station 4651. Peru: west of Aguja Point, 111 miles. 2,222 fms. Bott. temp. 35.4°. Stky. fne. gy. s., trace of shore-mud.

Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.

Eight specimens.

Synallactes triplax,[1] sp. nov.

Plate 4, fig. 14–17.

Length, 60 mm.; diameter, less than 20 mm. Color, pale gray, nearly white. General appearance much as in *S. aenigma* but pedicels larger and

[1] τρίπλαξ = triple, in reference to the triradiate calcareous tables.

more conspicuous on ventral surface; there are two well-marked series in each of the three ventral ambulacra. In each of the dorsal ambulacra is a double row of conical papillae. Tentacles twenty, rather small. Calcareous ring very well developed: interradial pieces wider than high with a conspicuous anterior point; radial pieces much larger with a strongly concave posterior margin and two conspicuous, truncate anterior projections. No ampullae on the tentacles. Respiratory trees well developed. Genital glands in two tufts, one on each side of the dorsal mesentery. Anus terminal and not sunken in a vertical furrow.

Calcareous particles, crowded tables with simple spires (Plate 4, fig. 14) of three rods united by three cross-bars but with the points free, straight and parallel; disks triradiate, in the typical condition (Plate 4, fig. 15) with three large oval perforations and a second series of three somewhat smaller holes alternating with them; usually, however, a third, often a fourth and not rarely a fifth series of perforations is present (fig. 16); diameter of disk 150–500 μ, but usually 250–400; height of spire equals disk-diameter or somewhat less. In many of the larger tables, the primary perforations are never closed in distally, so the disk remains a triradiate plate (Plate 4, fig. 17), with the outer end of each bar dichotomously branched and the final expansion perforated with 1–4 holes.

Station 4642. Galapagos Islands: Hood Island, 4 miles southeast of Ripple Point. 300 fms. Bott. temp. 48.6°. Brk. sh., glob.

One specimen.

This species is notable for the relatively shallow water in which it lives and the high bottom temperature of its habitat. It is closely related to several of the recently described Japanese species of Synallactes, particularly to *discoidalis* Mitsukuri. It differs from this form, however, in having fewer papillae and pedicels; four rows of papillae instead of six, and only two series of midventral pedicels instead of four to six. The tables are larger than in *discoidalis*, in which species the disk is only about 175 μ across, and the spire is quite different, as the three rods composing it are more or less fused in the Japanese species.

Pseudostichopus mollis.

Théel, 1886. Challenger Hol., pt. 2, p. 169.

These specimens are 20–125 mm. in length and show the usual diversity of this species in the condition of the body-wall and its surface. Some are firm,

almost hard with a perfectly smooth surface, showing no pedicels or adherent particles; others are less firm and show numerous pedicels and more or less adherent foreign material; still others are soft and flaccid, often with so much adherent material as to obscure the pedicels. All agree, however, in the absence of calcareous particles in the skin and in the presence of the vertical groove for the anus. The species of Pseudostichopus are perplexing but I see no good reason why these specimens should not all be referred to *mollis*. The differences between them are almost certainly artificial, except such as are due to age.

Station 4641. Galapagos Islands: Hood Island, 12 miles southeast of Ripple Point. 633 fms. Bott. temp. 39.5°. Lt. gy. glob. oz.
Station 4647. Eastern Tropical Pacific, 4° 33′ S., 87° 42′ 30″ W., 2,005 fms. Bott. temp. 35.5°. Lt. gy. and br. glob. oz.
Station 4656. Eastern Tropical Pacific, 6° 54′ 36″ S., 83° 34′ 18″ W., 2,222 fms. Bott. temp. 35.2°. Fne. gn. m., mang. nod.
Station 4672. Peru: southwest of Palominos Light House, 88 miles. 2,845 fms. Bott. temp. 35.2°. Fne. dk. br. infus. m.

Twelve specimens.

Stichopus chloronotus.

Brandt, 1835. Prod. descr. Anim., p. 250.

A single specimen of this wide-spread Indopacific species was taken at Uola, Caroline Islands, February 15, 1900.

Stichopus variegatus.

Semper, 1868. Holothurien, p. 73.

It is a matter of no little interest that this well-known Indopacific species was found at Easter Island, December 21, 1904. The known range is thus extended many hundred miles to the southeastward. The specimen is a large one but strongly contracted.

Holothuria arenicola.

Semper, 1868. Holothurien, p. 81.

A single specimen about 80 mm. long was taken at Perico Island, Panama, October 26, 1904. The species was previously known from the Galapagos and its occurrence at Panama is therefore not surprising, but it is quite possible that comparison of good series from the East Indies, the Galapagos, and Panama will show specific differences not at present suspected. Fisher (1907, Proc. U. S. Nat. Mus., **32**, p. 664) has pointed out that the name *maculata* Brandt which has long priority over *arenicola*, is invalidated by *Holothuria maculata*

Chamisso and Eysenhardt, 1821. The fact needs emphasis, as Ludwig's very careful and important revision of Brandt's species has so generally validated Brandt's names.

Holothuria atra.

Jaeger, 1833. De Holothuriis, p. 22.

This very abundant species is represented in both the collections. It was taken at Rangiroa, Paumotu Islands, September 21, 1899 and at Manga Reva, Paumotu Islands, February 3, 1905. The latter would seem to be the farthest to the southeast that the species is known to range.

Three specimens.

Holothuria cinerascens.

Stichopus (Gymnochirota) cinerascens Brandt, 1835. Prod. descr. Anim., p. 251.
Holothuria cinerascens Lampert, 1885. Die Seewalzen, p. 82.

A single specimen of this species, long known under Selenka's familiar name *pulchella*, was taken on the coral reef at Manga Reva, February 3, 1905. The record extends the known range far to the southeast.

Holothuria difficilis.

Semper, 1868. Holothurien, p. 92.

Fifteen small specimens which seems to be this species were taken at Makemo, Paumotu Islands, October 20, 1899. The resemblance in the general appearance and in the calcareous particles with those of *H. captiva*, *H. frequentiamensis*, and *Actinopyga parvula* are very striking, and suggest that the four names represent a single species. Examination of good series of specimens from numerous localities will be necessary to get the matter cleared up.

Holothuria imitans.

Ludwig, 1875. Arb. Zool. Zoot. Inst. Wurzburg, 2, p. 109.

There is a deep brown holothurian, 110 mm. long by 30 mm. in diameter, in the 1904–1905 collection labeled "114." I am unable to find any interpretation of this label for on November 4, if the figures are a date, the Albatross was dredging in more than 1,700 fms. between Panama and the Galapagos, and the specimen is obviously a littoral form. The calcareous particles are tables alone, save for supporting rods in the numerous pedicels which cover the whole body. The tables are very different from those of *languens* and while they also differ from Ludwig's figure of the tables of *imitans*, they are so much

nearer the latter, I refer the specimen to that species, though not without some doubt. The tables have an annular disk with eight distinct spines, and a distinctly smaller top with twelve to twenty teeth; the rods composing the spire diverge basally, not converging as in *languens*.

Holothuria impatiens.

Fistularia impatiens Forskål, 1775. Desc. Anim., p. 121.
Holothuria impatiens Gmelin, 1788. Syst. Nat. Linn. ed. 13, p. 3,142.

This is another of the common wide-spread Indopacific species occurring in both collections. It was taken in the Paumotu Islands at Fakarava, October 12, 1899, and again at Makemo, October 20. On February 3, 1905, a specimen was found at Manga Reva, Paumotus, notable for its color, seal-brown with the papillae cream-color. The specimens are all much contracted. Four specimens.

Holothuria languens.

Selenka, 1867. Zeits. f. w. Zool., **17**, p. 335.

This well-known Panamic species is represented in the 1904–1905 collection by three specimens, 15–40 mm. long, all much contracted and in poor condition. Two are from Taboguilla Island, Panama, October 31, 1904, and the third was collected at Perico Island, Panama, October 26, 1904.

Holothuria leucospilota.

Stichopus (*Gymnochirota*) *leucospilota* Brandt, 1835. Prod. descr. Anim., p. 251.
Holothuria leucospilota Lampert, 1885. Die Seewalzen, p. 71.

This species, so long known under Selenka's familiar name, *vagabunda*, must unquestionably bear Brandt's much earlier name, though both Lampert and Théel refused to recognize such a change. Four specimens were taken during the voyage of 1899–1900, the localities being:—

Rangiroa, Paumotus, September 21, 1899.
Maketea, Paumotus, October 6, 1899.
Fakarava, Paumotus, October 2, 1899.
Ponape, Caroline Islands, February 12, 1900.

Holothuria lubrica.

Selenka, 1867. Zeits. f. w. Zool., **17**, p. 329.

This well-known Panamic species is represented in the 1904–1905 collection by five specimens. There is some diversity of color but the general shade is brown, darkest dorsally; in one specimen, blackish spots on the dorsal side

are fairly distinct. As a rule the distinction between the dorsal and ventral surfaces is very marked but this is not always the case. The specimens were taken at Taboquilla and Perico Islands, Panama, in October, 1904.

Holothuria marenzelleri.

Ludwig, 1883. Ber. d. oberh. Ges. f. Naturk., **22**, p. 167.

A single specimen was taken at Chatham Island, in the Galapagos, in January 1905. It measures 100 mm. in length by 35–40 mm. in diameter. The species has been recorded previously from the Galapagos Islands, although it was originally described from the East Indies.

Holothuria monocaria.

Lesson, 1830. Cent. Zool., p. 225.

The specimens which I refer (though not without hesitation) to this common species are quite young, one about 40 mm., the other only 11 mm. long. The larger is nearly white and is possibly from Tahiti but nothing is certain as to the locality beyond the fact that the specimen was collected by the 1899–1900 expedition. There are very few buttons in the skin and the tables show considerable diversity of form. The smaller specimen is also nearly white. It was taken October 12, 1899, at Fakarava, Paumotu Islands. The tables are well formed but diversified with eight to thirteen marginal holes in the disk. There are apparently *no* buttons in the skin. If these specimens really are *monocaria* it would seem to be probable that tables arise some time before buttons and that the buttons only gradually become so numerous as to form the layer present in adults. But of course, only a series of indubitable growth-stages can determine whether this is the case.

Holothuria pardalis.

Selenka, 1867. Zeits. f. w. Zool., **17**, p. 336.

A single specimen taken October 20, 1899 at Makemo, Paumotu Islands, seems to belong to this species but the condition is poor and the calcareous particles are so corroded that it is impossible to be sure of the identification.

Holothuria scabra.

Jaeger, 1833. De Holothuriis, p. 23.

A single specimen of moderate size was taken at Guam, Ladrone Islands, February 27, 1900.

Actinopyga lecanora.

Mülleria lecanora Jaeger, 1833. De Holothuriis, p. 18.
Actinopyga lecanora Bronn, 1860. Thierreich, **3**, p. 403.

A specimen of this wide-spread Indopacific species was taken February 3, 1905, at Manga Reva, Paumotu Islands, on the coral reef, thus extending the known range far to the southeastward. The specimen is now very strongly contracted but the specific characters are distinguishable without difficulty.

Actinopyga mauritiana.

Mülleria mauritiana Quoy et Gaimard, 1833. Astrolabe Zooph., p. 138.
Actinopyga mauritiana Fisher, 1907. Proc. U. S. Nat. Mus., **32**, p. 648.

It is rather remarkable that while the 1899–1900 expedition brought home six specimens of this well-known species from at least four islands in the Society and Paumotu groups, the species was apparently not met with by the later expedition, although the latter took the preceding species at Manga Reva. The specimens are chiefly large adults but the one from Fakarava is only 20 mm. long and one from Papeete is less than half grown. The latter is notable for being colored like *lecanora*, the area around the anus being abruptly and conspicuously lighter than the ground-color of the body. The smallest specimen is of unusual interest because there are few grains in the ventral skin and the rods there are larger than those of the dorsal surface. If the identification of this specimen is correct, the characteristic ventral grains do not appear until the animal is more than 20 mm. long. No doubt the growth-stages of this Actinopyga would afford a very interesting study. The specimens in the present collection were taken at:—

Rangiroa, Paumotus, September 23, 1899.
Papeete, Tahiti, Society Islands, September 28, 1899.
Makatea, Paumotus, October 6, 1899.
Fakarava, Paumotus, October 12, 1899.

Actinopyga parvula.

Mülleria parvula Selenka, 1867. Zeits. f. w. Zool., **17**, p. 314.
Actinopyga parvula Fisher, 1907. Proc. U. S. Nat. Mus., **32**, p. 645.

There are sixteen small specimens 15–35 mm. long, collected at Easter Island, December 20, 1904, which seem to belong to this remarkably wide-spread species. The color ranges from brown to almost black dorsally, but is generally lighter ventrally. Some specimens show distinct blotches of darker color on the back. All the specimens have anal teeth but all five teeth are not equally developed in every case. This little holothurian is certainly a puzzle. It

occurs in the West Indian region where *Holothuria captiva*, from which it can scarcely be distinguished except by the anal teeth, is common. It occurs in the Indopacific region with *Holothuria difficilis* from which again the anal teeth are its one distinguishing character. On the other hand, it is utterly unlike any other Actinopyga save for the presence of the anal teeth. Pearsons is almost certainly right in removing it from Actinopyga but he throws no light on the problem of its relation to the species of Holothuria mentioned. Possibly the presence of anal teeth is, in this case, not even a valid specific character but it is hard to believe this is the case. At any rate, the occurrence of this perplexing form, originally described from Florida, on the shores of Easter Island is a matter of unusual interest.

Summary of the Echinoderms collected by the Agassiz-Albatross Tropical Pacific Expeditions of 1891, 1899–1900 and 1904–1905.

As the present report is the last of those dealing with the Echinoderms collected by Mr. Agassiz on his Tropical Pacific Expeditions, it is fitting that the chief additions to our knowledge of the taxonomy of the Echinodermata should be summarized.

The Crinoids proved to be the least abundant of the five classes and only *nine* species were taken. Of these *two* were unidentifiable but *six* of the others were new. There is no record of the number of specimens. The most notable of the crinoids are the two stalked forms *Bathycrinus equatorialis* A. H. Clark and *Calamocrinus diomedae* A. Agassiz. The latter, one of the most notable stalked crinoids as yet taken, was made the subject of a detailed monograph (Agassiz, 1892, Mem. M. C. Z. **17**, no. 2).

The Asteroids were fairly numerous but there were few species of extraordinary interest. In all more than 1,300 specimens were brought home, representing *ninety* species, of which *sixty-nine* were new. Of new genera, *five* were established. The most notable forms are probably the two species of the new genus Albatrossia, the numerous species of Hymenaster, and Zoroaster, and the Brisingidae.

The Ophiurans were numerous both in specimens and species but unfortunately there is no complete record of the number of specimens. There were at least *ninety-seven* species taken, and of these *sixty* were new. One new genus was described based on this material. The most noteworthy brittle-stars are *Gymnophiura mollis*, *Sigsbeia lineata*, and *Ophioderma pentacantha*.

The ECHINI were represented by *forty* species, a very large number in proportion to the total number of species known. There is no means of determining how many specimens were taken as there are no available records on this point. *Ten* of the species brought home are common littoral species of wide range but of the other *thirty*, no fewer than *twenty-nine* were new when taken and all but one of these is from deep water. Undoubtedly the most remarkable sea-urchin discovered is *Pilematechinus rathbuni*, but *Centrocidaris doederleini*, *Dialithocidaris gemmifera*, *Plexechinus cinctus*, and *Phryssocystis aculeata* are also of exceptional interest, each being the type of a new genus.

The HOLOTHURIANS were the most generally met with of any of the classes of echinoderms and the records show that 953 were in the collections brought home. These represented *seventy-nine* different species many of which are common littoral forms of wide range but *forty-three* were described as new. Of course the most remarkable is the extraordinary *Pelagothuria natatrix*, sole representative of a pelagic family and the only echinoderm known to be truly pelagic in adult life. Other noteworthy holothurians, knowledge of which we owe to these explorations of the ALBATROSS, are two abyssal species of Myriotrochus, the huge *Psychropotes raripes*, *Laetmophasma fecundum*, *Capheira sulcata*, and *Echinocucumis bitentaculata*.

Summing up for the five classes, we find that the ALBATROSS, on her three Tropical Pacific expeditions, collected several thousand echinoderms, representing 315 species, of which 207, or more than two thirds, were new. The increase in our knowledge of the morphology and distribution, both geographical and bathymetrical, of the group, which we owe to these expeditions, cannot be summarized in this rough and ready way, but one cannot turn the pages of the following reports, wherein they are treated, without realizing how great it is.

List of the Reports based wholly or in part on the Echinoderms collected by the ALBATROSS *Tropical Pacific Expeditions in 1891, 1899–1900, and in 1904–1905*

CRINOIDS.

A. Agassiz, 1892. Mem. M. C. Z., **17**, no. 2, p. 1–95, pl. 1–32.

C. Hartlaub, 1895. Bull. M. C. Z., **27**, p. 127–152, pl. 1–4.

A. H. Clark, 1908. Bull. M. C. Z., **51**, p. 231–248, pl. 1, 2.

ASTEROIDS.

H. Ludwig, 1905. Mem. M. C. Z., **32**, 304 pp., pl. 1–36.

H. Ludwig, 1907. Zool. anz., **31**, p. 312–319.

H. L. Clark, 1920. Mem. M. C. Z., **39**, p. 69–114, pl. 1–6.

Ophiurans.

C. F. Lütken and T. Mortensen, 1899. Mem. M. C. Z., **23**, p. 93–207, pl. 1–23.

H. L. Clark, 1917. Bull. M. C. Z., **61**, p. 427–453, pl. 1–5.

Echini.

A. Agassiz, 1898. Bull. M. C. Z., **32**, p. 69–86, 14 pls.

A. Agassiz, 1904. Mem. M. C. Z., **31**, 253 pp., 112 pls.

A. Agassiz and H. L. Clark, 1907–1909. Mem. M. C. Z., **34**, 210 pp., pl. 1–89.

A. Agassiz, 1908. Mem. M. C. Z., **39**, p. 1–34, 49 pls.

A. M. Westergren, 1911. Mem. M. C. Z., **39**, p. 35–68, pl. 1–38.

H. L. Clark, 1912. Mem. M. C. Z., **34**, p. 205–383, pl. 90–121.

H. L. Clark, 1914–1917. Mem. M. C. Z., **46**, p. 1–283, pl. 122–161.

Holothurians.

H. Ludwig, 1893. Zool. anz., **16**, p. 177–186. Bull. M. C. Z., **24**, p. 103–114.

H. Ludwig, 1894. Mem. M. C. Z. **17**, no. 3, p. 1–183, pl. 1–19.

H. L. Clark, 1920. Mem. M. C. Z., **39**, p. 115–154, pl. 1–4.

EXPLANATION OF THE PLATES.

PLATE 1.

PLATE 1.

1. **Psychropotes raripes** Ludwig.
   Large adult from Station 4721, seen from the side. About one half natural size.

2. **Euphronides verrucosa** Ludwig.
   Large adult from Station 4742, seen from above. About two thirds natural size.

A. Agassiz and A.M. Westergren del.

PLATE 2.

PLATE 2.

1. **Benthodytes glutinosa** R. Perrier.
   Adult from Station 4647, seen from below.

2. **Benthodytes regularis** H. L. Clark.
   Holotype from Station 4649, seen from above.

3. **Euphronides dyscrita** H. L. Clark.
   Adult, probably the holotype, from Station 4672, seen from above.

4. **Periamma tetramerum** H. L. Clark.
   Adult from Station 4670, seen from below.

5. **Cucumaria abyssorum** Théel.
   Adult from Station 4649, seen from the side, the ventral surface to the left.

All figures supposed to be natural size.

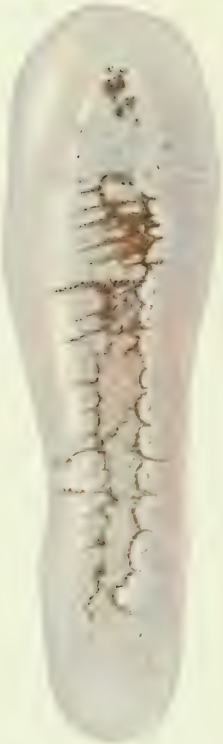

PLATE 3.

PLATE 3.

1. **Molpadia holothurioides** Cuvier?
   Adult from Station 4672, seen from the side. The absence of a caudal appendage is perhaps due to an accident.

2. **Molpadia bathybia** H. L. Clark.
   Paratype from Station 4670, seen from below.

3. **Parelpidia anamesa** H. L. Clark.
   Holotype from Station 4658, seen from below.

4. **Synallactes aenigma** Ludwig.
   Adult from Station 4649; the discarded and contracted skin seen from above.

5. **Molpadia** sp.
   Drawn from a specimen, no longer extant, taken at Station 4630.

6. **Scotoplanes murrayi** (Théel).
   Adult from Station 4651, seen from above.

All figures supposed to be natural size.

PLATE 4.

PLATE 4.

1, 2. **Chiridota aponocrita** H. L. Clark.
1. Supporting-rods of tentacles. × 450.
2. Miliary granules. × 450.

3. **Myriotrochus bathybius** H. L. Clark.
Calcareous wheel. × 95.

4. **Myriotrochus giganteus** H. L. Clark.
Calcareous wheel. × 95.

5, 6. **Molpadia bathybia** H. L. Clark.
Disks of tables. × 95.
Spire of a table, from the side. × 95.

7, 8. **Scotodeima parvispiculatum** H. L. Clark.
Calcareous particles. × 140.

9, 10. **Mesothuria megapoda** H. L. Clark.
9. Table, seen from the side. × 95.
10. Disk of table. × 95.

11–13. **Mesothuria multipora** H. L. Clark.
11. Table, seen from the side. × 95.
12. Disk of table. × 95.
13. Spire of table, seen from above. × 95.

14–17. **Synallactes triplax** H. L. Clark.
14. Typical table seen from the side. × 95.
15. Disk of typical triradiate table. × 95.
16. Disk of larger table. × 95.
17. Disk of an "unclosed" table. × 95.

H. L. Clark del.

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